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MINISTRY OF SKILL DEVELOPMENT
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Participant Handbook

Sector
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Sub-Sector
Network Managed Services

Occupation
Network Pperation and Maintenance

Reference ID: **TEL/Q6211, Version 2.0**
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Drive Test Engineer

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Telecom Sector Skill Council of India

Estel House, 3rd Floor, Plot No:- 126, Sector 44

Gurugram, Haryana 122003

Phone: 0124-2222222

Email: tssc@tsscindia.com

Web: www.tsscindia.com

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Skilling is building a better India.
If we have to move India towards development then Skill Development should be our mission.

Shri Narendra Modi
Prime Minister of India

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कौशल भारत-कुशल भारत

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Certificate

COMPLIANCE TO QUALIFICATION PACK – NATIONAL OCCUPATIONAL STANDARDS

is hereby issued by the

TELECOM SECTOR SKILL COUNCIL OF INDIA

for

SKILLING CONTENT: PARTICIPANT HANDBOOK

Complying to National Occupational Standards of
Job Role/ Qualification Pack: **'Drive Test Engineer'** QP No. **'TEL/Q6211, NSQF Level 5'**

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(Telecom Sector Skill Council of India)

Acknowledgements

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The preparation of this handbook would not have been possible without the Telecom Industry's support. Industry feedback has been extremely encouraging from inception to conclusion and it is with their input that we have tried to bridge the skill gaps existing today in the industry.

This participant handbook is dedicated to the aspiring youth who desire to achieve special skills which will be a lifelong asset for their future endeavours.

About this book

India is currently the world's second-largest telecommunications market with a subscriber base of 1.20 billion and has registered strong growth in the last decade and a half. The Industry has grown over twenty times in just ten years. Telecommunication has supported the socioeconomic development of India and has played a significant role in narrowing down the rural-urban digital divide to some extent. The exponential growth witnessed by the telecom sector in the past decade has led to the development of telecom equipment manufacturing and other supporting industries.

Over the years, the telecom industry has created millions of jobs in India. The sector contributes around 6.5% to the country's GDP and has given employment to more than four million jobs, of which approximately 2.2 million direct and 1.8 million are indirect employees. The overall employment opportunities in the telecom sector are expected to grow by 20% in the country, implying additional jobs in the upcoming years.

This Participant handbook is designed to impart theoretical and practical skill training to students for becoming Drive Test Engineer in the Telecom Sector.

Drive test engineer or the DT engineer is the person who is responsible for maintaining the networks functionality and efficiency

This Participant Handbook is based on Drive Test Engineer Qualification Pack (TEL/Q6211) and includes the following National Occupational Standards (NOSs):

1. TEL/N6237 – Tower site verification and preparation for drive test
2. TEL/N6238 – Tower site performance measurement and parameter recording
3. TEL/N6239 – Tower site data analysis and reporting
4. TEL/N6240 – Tower Site Optimization and troubleshooting
5. TEL/N9103 – Implement effective interaction between team members and customers
6. TEL/N9104 – Manage work and safety at workplace

The Key Learning Outcomes and the skills gained by the participant are defined in their respective units.

Post this training, the participant will be able to manage the counter, promote and sell the products and respond to queries on products and services.

We hope this Participant Handbook will provide sound learning support to our young friends to build an attractive careers in the telecom industry.

Symbols Used

Key Learning Outcomes

Unit Objectives

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1. Role and Responsibilities of a Drive Test Engineer

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Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Outline the current situation of the Indian telecom industry and its growth
2. Evaluate the expansion of the telecom tower industry in India
3. Distinguish various segments of the telecom sector, i.e., passive infra and active networks
4. Analyse the fundamentals of Global System for Mobile (GSM), Universal Mobile Telecommunication Service (UMTS), and Long-Term Evolution (LTE)
5. Illustrate different technologies based on architecture – 2G GSM, 3G, 4G/VoLTE network
6. Classify the various logic channels in the active networks
7. Explain the call flow process in 2G and 3G

UNIT 1.1: Introduction to the Telecom Tower Industry

Unit Objectives

By the end of this unit, the participants will be able to:

1. Discuss about the current scenario of the Indian Telecom industry
2. Analyse the growth of the telecom tower industry in India

1.1.1 Introduction to Telecom Industry in India

India holds a leading position in the current global telecommunications market. Subscribers have grown progressively since that past decade and are currently 1.2 billion. According to a report produced by the GSM Association (GSMA), there has been a steady increase in the contribution of the telecom economy to India's Gross Domestic Product (GDP). App downloads in the country witnessed a growth of around 215 per cent between 2015 and 2017, and India's smartphone market witnessed a yearly growth of 14%. It is estimated that by 2020, the gross economic value created by the mobile industry will be around ₹14 a trillion (US$ 217.37 billion).

Reduced data costs coupled with increasing mobile phone penetration will lead to 500 million new internet users in India, which in turn creates scope for new trades. The data usage per smartphone on a monthly basis in India is forecasted to grow from approximately 3.9 GB (in2017) to around 18 GB by 2023. With a subscriber base increasing daily, a lot of developments and investments are made in the sector. The industry has seen an FDI of around US$ 30.08 billion from April 2000 to December 2017.

As per a recent report by Microsoft, by 2025, India will have 700 million internet users among 4.7 billion global users, thereby establishing itself as the market leader. The internet economy is expected to reach ₹.10 trillion by 2018, contributing about 5 per cent to the country's GDP. Favourable policies, such as the launch of 4G services, will result in the rapid growth of the Indian telecommunication sector.

To promote initiatives such as Machine-to-Machine communications, Internet of Things (IoT), Instant High Definition Video Transfer, and Smart Cities initiative, the government is planning to auction the 5G spectrum. The boost to the production of battery chargers will lead to the setting up of 365 factories, thereby generating 800,000 jobs in the Indian telecom industry by 2025.

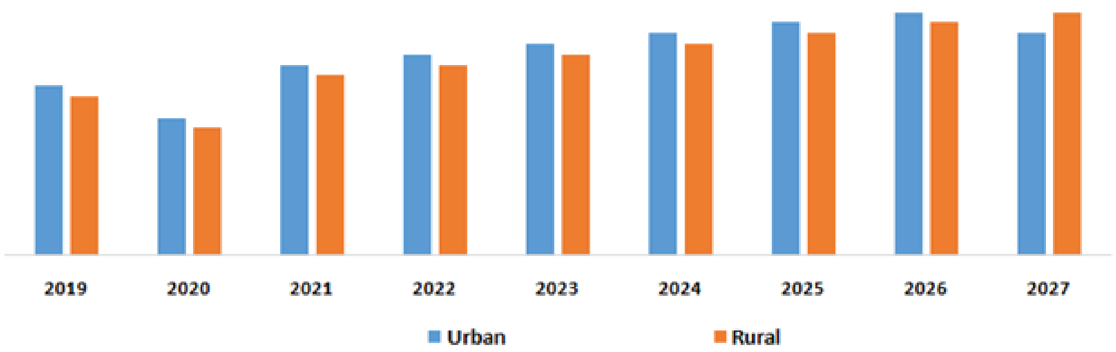


Fig. 1.1.1: Indian Telecommunication Market Share – Urban & Rural

1.1.2 Telecom Tower Industry in India

The rapid growth of the Telecom Industry and the considerable increase in the number of subscribers have given ample reasons for the Telecom Tower Industry to flourish and establish itself as one of the aces of the economic market in India. This has been possible because:

- The initiatives taken by the Indian Government have benefitted the telecom tower industry. For instance, the foreign investment policies and the outsourcing infrastructure have affiliated the telecom tower industry to grow fast.
- The competition in the Telecom industry (due to an expansion of subscriber base and operators) has indirectly helped the Telecom Tower Industry to flourish.
- The reduction in the cost of operation and outsourcing of the business has proved to be of significant advantage in the growth of the Telecom Tower Industry.
- The network operators more often collaborate with the tower companies, if not own them. It helped the tower companies to grow their businesses as well. Even today, 90% of the network providers own towers which is a healthy sign for the tower companies.

Roles of Tower Companies

The roles and responsibilities of the tower companies are as follows:

- Site planning (surveying and marking a site suitable to install towers)
- Site acquisition and obtaining legal approvals (after site planning is done, the acquisition comes in the scenario. The tower companies should buy the site, if not hire, along with proper legal documents)
- Site erection (installing the tower with the help of concerned departments and personnel)
- Commissioning the tower (the tower should be canvassed in case any network operator does not own it)

Major tower companies in India

There are many players in the Indian market when it comes to tower setup. However, the below list shows the major players in the Indian tower market.

- Indus Towers Ltd.
- Aster Pvt. Ltd.
- GTL Infrastructure Ltd.
- HFCL Ltd.
- ITI Ltd.
- Mahanagar Telephone Nigam Ltd. (MTNL)
- Tower Vision India Pvt. Ltd.
- Tata Communications Ltd.
- Tata Teleservice Ltd.
- Tejas Networks Ltd.

UNIT 1.2: Fundamentals of GSM/UMTS/LTE Architecture

Unit Objectives

By the end of this unit, the participants will be able to:

1. Identify various segments of the telecom sector, i.e., passive infra and active networks
2. Discuss about different mobile networks and technologies
3. Explain the fundamentals of GSM
4. Identify the components of a network architecture of UMTS
5. Explain the basics of LTE

1.2.1 Passive Infra and Active Network

Active

An active network requires power; hence, they need a power source. Mostly it is in the form of an AC or DC power system that's backed up by batteries. The power can be circulated to a variety of equipment. In addition to the active equipment, a typical enclosure can have an electrical panel, grounding system, wiring, AC and/or DC wiring circuits, and a way to hook up a generator.

Active equipment includes equipment like switches, wireless routers, transceivers, firewalls, premises equipment, amplifiers, HFC equipment, networking hardware, energy equipment and other active equipment required to have your network running efficiently and reliably.

Passive

Passive Infrastructures are the infrastructures that are not part of a Telecommunications Network's active layer, including sites, buildings, shelters, towers, masts, poles, ducts, trenches, electric power supply, and air conditioning.

Passive infrastructure is also called transmission media or physical layer. How data travels from point A to B relies on the infrastructure technology used; whether it's in an:

- Building
- Multi Dwelling Unit (MDU) or Single-Family Unit (SFU)
- Stadium, arena, or campus
- Central office, head-end or data centre
- The many types of wired or wireless outside plant (OSP) networks

1.2.2 Different Mobile Networks and their Technologies

The aim of wireless communication is to provide high-quality, reliable communication just like wired communication (optical fibre), and each new generation of services represents a big step in that direction. This evolution journey started from 1G in 1980 and is still continuing to 5G.

Generations of Mobile Networks: Explained

Each generation of networks brought a significant milestone in the development of mobile communications, the benefits of which are listed below. Analogue mobile networks are the First-

Generation Networks introduced in the early 1980s. One of the most popular technology standards for first-generation mobile networks is the Advanced Mobile Phone System (AMPS).

First Generation (1G)

First-generation mobile networks relied on analogue radio systems, which meant that users could only make phone calls. They couldn't send or receive text messages. The 1G network was first introduced in Japan in 1979 before it was rolled out in other countries, such as the U.S.A., in 1980. Cell towers were built across the country to make it work, which ensured that signals could be obtained from greater distances. However, the network was unreliable and had several security issues. For example, cell coverage would often drop, it would experience interference by other radio signals, and it could easily be hacked due to a lack of encryption. This means that conversations can be heard and recorded with a few tools.

One of the most popular technology standards for first-generation mobile networks is the Advanced Mobile Phone System (AMPS).

Second Generation (2G)

The 1G network was replaced with 2G in 1991. This new mobile network ran on the digital signal, not analogue, which vastly improved its security and capacity. On 2G, users could send SMS and M.M.S. messages (although slowly and often without success), and when GPRS was introduced in 1997, users could receive and send emails on the move.

The most popular Technology standards are GSM/CDMA, GPRS/EDGE/IS95-B.

Third Generation (3G)

Third-generation mobile networks are still being used today, but normally when the superior 4G signal fails. 3G revolutionised mobile connectivity and the abilities of cell phones.

Compared to 2G, the 3G was much faster and could transmit a greater volume of data. This meant that users could video call, share files, surf the internet, watch T.V. online and play online games on their mobiles for the first time. Under 3G, cell phones were no longer just about calling and texting; they were the hub of social connectivity. The technology used in 3G is WCDMA (Wideband Code Division Multiple Access), Digital Broadband Packet Data CDMA 2000, and UMTS.

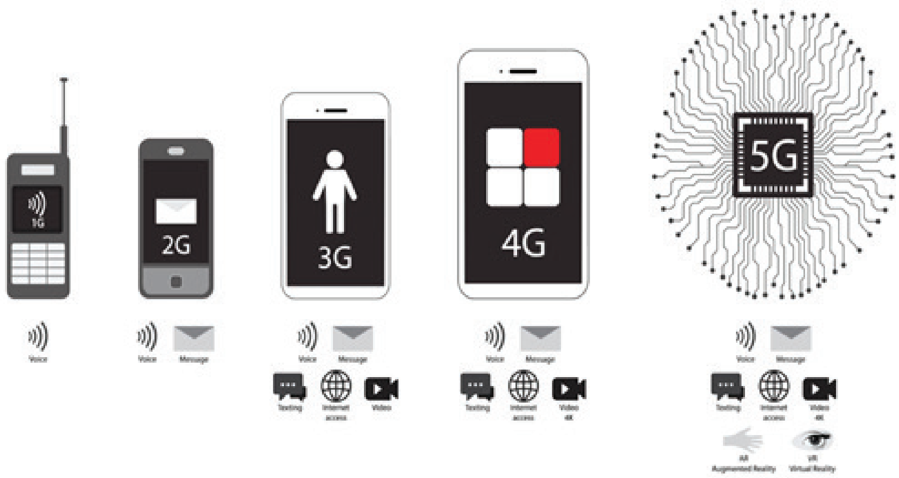


Fig. 1.2.1: Mobile Network Generations

Fourth Generation (4G)

The arrival of 4G went beyond the revolutionary 3G as it is five times faster than the 3G network and can (in theory) provide speeds of up to 100Mbps. All mobile models released from 2013 onwards should support this network, which can offer connectivity for tablets, laptops, and smartphones. Using 4G, one can experience better latency (less buffering), higher voice quality, easy access to instant messaging services and social media, quality streaming, and faster downloads. The technology used in 4G is LTE(Long-Term Evolution) and WiMAX(Worldwide Interoperability for Microwave Access).

Fifth Generation (5G)

The 5G network has already crossed its development phase and is widely anticipated by the mobile industry as well as by consumers. Many experts claim that the network will change how we use our mobiles and connect our devices to the internet. The enhanced speed and capacity of the network will signal new IoT trends, such as connected cars, smart cities and IoT in the home, malls and office.

Analogue mobile networks are the First Generation Networks introduced in the early 1980s. One of the most popular technology standards for first-generation mobile networks is the Advanced Mobile Phone System (AMPS).

The second (2G), third (3G), fourth (4G), and fifth (5G) generations of mobile networks are digital mobile networks that employ digital cellular technologies, including GSM, D-AMPS, IS-95, UMTS, CDMA2000, LTE and N.R. Digital mobile networks use TDMA, CDMA and OFDMA radio access techniques.

Features	1G	2G	3G	4G	5G
Start/ Development	1970/1984	1980/1999	1990/2002	2000/2010	2010/2015
Technology	AMPS, NMT, TACS	GSM	WCDMA	LTE, WiMax	MIMO, mm Waves
Frequency	30 kHz	1.8 GHz	1.6 – 2 GHz	2 – 8 GHz	3 – 30 GHz
Bandwidth	2 kbps	14.4 – 64 kbps	2 Mbps	2000 Mbps to 1 Gbps	1 Gbps and higher
Access System	FDMA	TDMA/CDMA	CDMA	CDMA	OFDM/BDMA
Core network	PSTN	PSTN	Packet Network	Internet	Internet

Table 1.2.1: Mobile Generations Comparison Chart

1.2.3 GSM Overview

Global System for Mobile Communication is a digital cellular technology used for transmitting mobile voice and data services.

The concept of GSM emerged from a cell-based mobile radio system at Bell Laboratories in the early 1970s. GSM is the name of a standardisation group formed in 1982 to create a standard European mobile telephone standard. Today, GSM is the most widely accepted standard in telecommunications worldwide.

GSM is a circuit-switched system that divides each 200 kHz channel into eight 25 kHz time slots. It operates on the mobile communication bands 900 MHz and 1800 MHz in most parts of the world.

GSM owns a market share of more than 70 per cent of the world's digital cellular subscribers. It makes use of the narrowband Time Division Multiple Access (TDMA) technique for transmitting signals. It has the ability to carry 64 kbps to 120 Mbps of data rates.

GSM currently supports over one billion mobile subscribers in more than 210 countries. It provides basic to advanced voice and data services, including roaming services.

GSM digitises and compresses data, then sends it down through a channel with two other streams of user data, each in its own timeslot.

Listed below are the features of GSM that account for its popularity and wide acceptance.

- Improved spectrum efficiency
- International roaming
- Low-cost mobile sets and base stations (B.S.s)
- Higher speech quality
- Compatibility with Integrated Services Digital Network (ISDN) and other telephone company services
- Support for new services

GSM Architecture

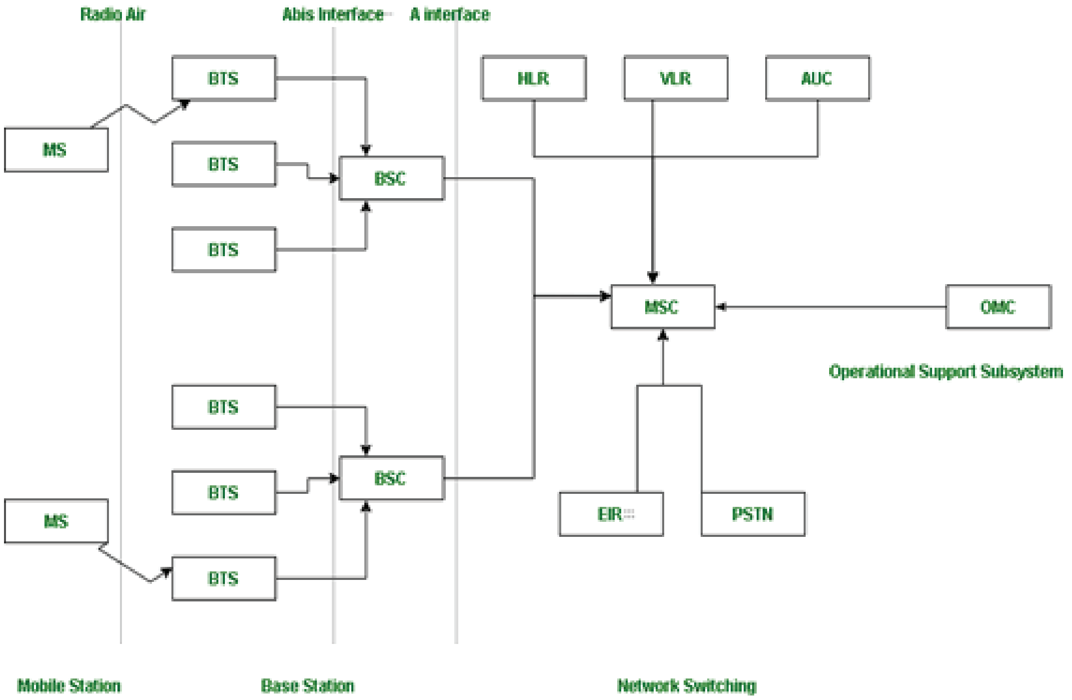


Fig. 1.2.2: Structure of a GSM network

A GSM network comprises of many functional units, which can be broadly divided into:

- The Mobile Station (M.S.)
- The Base Station Subsystem (B.S.S.)
- The Network Switching Subsystem (N.S.S.)
- The Operation Support Subsystem (O.S.S.)

GSM – The Mobile Station

The MS consists of physical equipment, such as display and digital signal processors, radio transceivers, and SIM cards. It provides the air interface to the user in GSM networks, and other services are also provided, which include:

- Data bearer services
- Voice teleservices
- Features' supplementary services

The Mobile Station also provides the receptor for SMS messages, enabling the user to toggle between voice and data use. Moreover, the mobile facilitates access to voice messaging systems. It also provides access to the various data services available in a GSM network. These data services include:

- X.25 packet switching using a synchronous or asynchronous dial-up connection to the P.A.D. at speeds typically at 9.6 Kbps.
- General Packet Radio Services (GPRS) use an X.25 or I.P. based data transfer method at speeds up to 115 Kbps.
- High-speed, circuit-switched data at speeds up to 64 Kbps.

What is a SIM?

A SIM provides personal mobility so that the user can access all subscribed services irrespective of the terminal's location and the use of a specific terminal. You need to insert the SIM card into a GSM cellular phone to receive calls, make calls from that phone, or receive other subscribed services.

Base Station Subsystem (B.S.S.)

The B.S.S. is composed of two parts:

- Base Transceiver Station (B.T.S.)
- Base Station Controller (B.S.C.)

The B.T.S. and the B.S.C. communicate across the specified Abis interface, enabling operations between components that different suppliers make. The radio components of a B.S.S. may consist of four to seven or nine cells. A BSS may have one or more base stations. The B.S.S. uses the Abis interface between the Base Transceiver Station (B.T.S.) and the Base Station Controller (B.S.C.).

A separate high-speed line (T1 or E1) is then connected from the B.S.S. to the Mobile M.S.C.

Base Transceiver Station (B.T.S.)

The B.T.S. holds the radio transceivers that define a cell and handles the radio link protocols with the Mobile Station. In a large urban area, a large number of B.T.S.s may be deployed. The B.T.S. corresponds to the transceivers and antennas used in each cell of the network.

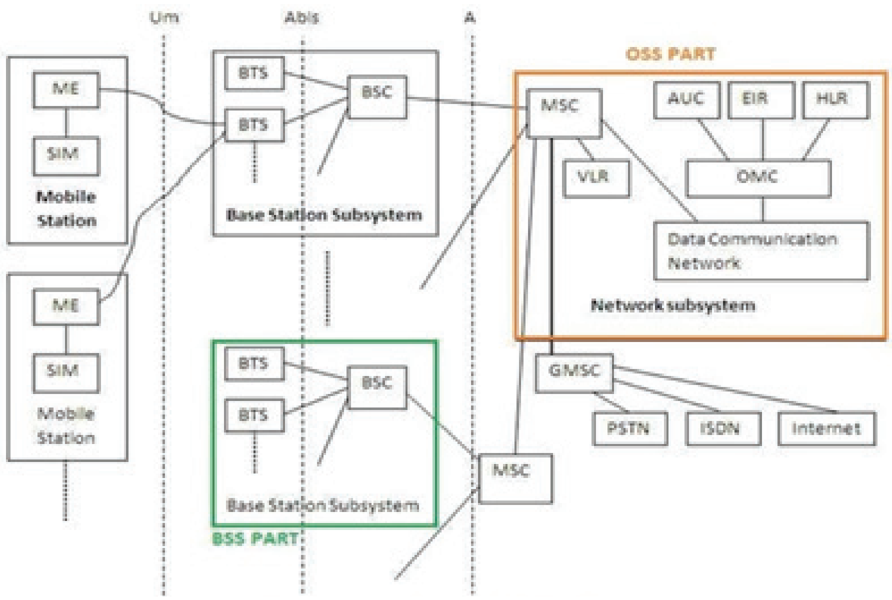


Fig. 1.2.3: GSM Architecture

A Base Transceiver Station (B.T.S.) is usually placed in the centre of a cell, and its transmitting power defines the size of a cell. Each B.T.S. has between 1 and 16 transceivers, depending on the density of users in the cell. Each B.T.S. serves as a single cell. It also includes the following functions:

- Encoding, encrypting, multiplexing, modulating, and feeding the R.F. signals to the antenna
- Transcoding and rate adaptation
- Time and frequency synchronising
- Voice through full- or half-rate services
- Decoding, decrypting and equalising received signals
- Random access detection
- Timing advances
- Uplink channel measurements

Fig. 1.2.4: Base Transceiver Station (BTS)

Base Station Controller (B.S.C.)

The B.S.C. manages the radio resources for one or more B.T.S.s. It handles radio channel setup, frequency hopping, and handovers. The B.S.C. is the connection between the mobile and the M.S.C. The B.S.C. also translates the 13 Kbps voice channel used over the radio link to the standard 64 Kbps channel used by the Public Switched Telephone Network (PSDN) or ISDN.

It assigns and releases frequencies and time slots for the M.S. The B.S.C. also handles intercell handover. It controls the power transmission of the B.S.S. and M.S. in its area. The function of the B.S.C. is to allocate the necessary time slots between the B.T.S. and the M.S.C. It is a switching device that handles the radio resources.

Fig. 1.2.5: Base Station Controler

The additional functions of the Base Station Controller (B.S.C.) include:

- Controlling frequency hopping
- Performing traffic concentration to reduce the number of lines from the M.S.C.
- Providing an interface to the Operations and Maintenance Centre for the B.S.S.
- Reallocation of frequencies among B.T.S.s
- Time and frequency synchronisation
- Power Management
- Time-delay measurements of received signals from the MS

GSM – Network Switching Subsystem (N.S.S.)

The Network switching system (N.S.S.), the main part of which is the Mobile Switching Centre (M.S.C.), performs the switching of calls between the mobile and other fixed or mobile network users, as well as the management of mobile services such as authentication.

Home Location Register (H.L.R.)

The H.L.R. is a database used for the storage and management of subscriptions. The H.L.R. is considered the most important database, as it stores permanent data about subscribers, including a subscriber's service profile, location information, and activity status. When an individual buys a subscription in the form of a SIM, then all the information about this subscription is registered in the H.L.R. of that operator.

Mobile Switching Centre (M.S.C.)

The central component of the Network Subsystem is the Mobile Switching Centre (M.S.C.). It switches calls between the mobile and other fixed or mobile network users and manages mobile services such as registration, authentication, location updating, handovers, and call routing to a roaming subscriber. It also performs toll ticketing, network interfacing, and common channel signalling. A unique I.D identifies every M.S.C.

Fig. 1.2.6: Mobile Switching Centre Room Equipment

Visitor Location Register (V.L.R.)

The V.L.R. is a database containing temporary information about subscribers that the M.S.C. needs to service visiting subscribers. The V.L.R. is always integrated with the M.S.C. When a mobile station roams into a new M.S.C. area, the V.L.R. connected to that M.S.C. will request data about the mobile station from the H.L.R. Later, if the mobile station makes a call, the V.L.R. will have the data needed for call setup without having to interrogate the H.L.R. each time.

Authentication Centre (A.U.C.)

The ACU is a protected database that stores a copy of the secret key stored in each subscriber's SIM card, which is used for authenticating and ciphering the radio channel. It protects network operators from different types of fraud found in today's cellular world.

Equipment Identity Register (EIR)

The Equipment Identity Register (EIR) is a database containing a list of all valid mobile equipment on the network. Here, the International Mobile Equipment Identity (IMEI) identifies each MS. An IMEI is marked as invalid if it has been reported stolen or is not type approved.

Fig. 1.2.7: Equipment Identity Register (EIR)

The Operation Support Subsystem (O.S.S.)

The operations and maintenance centre (O.M.C.) is connected to all switching system equipment, including the B.S.C. The implementation of O.M.C. is called the operation and support system (O.S.S.).

Here are some of the O.M.C. functions:

- Administration and Commercial Operation
- Network configuration, Operation, and Performance Management.
- Maintenance Tasks

The operation and maintenance functions are based on the Telecommunication Management Network (T.M.N.) concepts, which are standardised in the ITU-T series M.30.

1.2.4 UMTS (Universal Mobile Telecommunications Service)

UMTS is a third-generation (3G) broadband, packet-based transmission of text, digitised video, voice, and multimedia at data rates up to 2 megabits per second (Mbps). UMTS offers a steady set of services to mobile computer and phone users, no matter where they are located in the world. UMTS is based on the Global System for Mobile (GSM) communication standard.

UMTS uses wideband code division multiple access (W-CDMA) radio access technology to provide greater spectral efficiency and bandwidth for mobile network operators. The electromagnetic radiation spectrum for UMTS has been identified as frequency bands 1885-2025 MHz for future IMT-2000 systems, 1980-2010 MHz and 2170-2200 MHz for the satellite portion of UMTS systems.

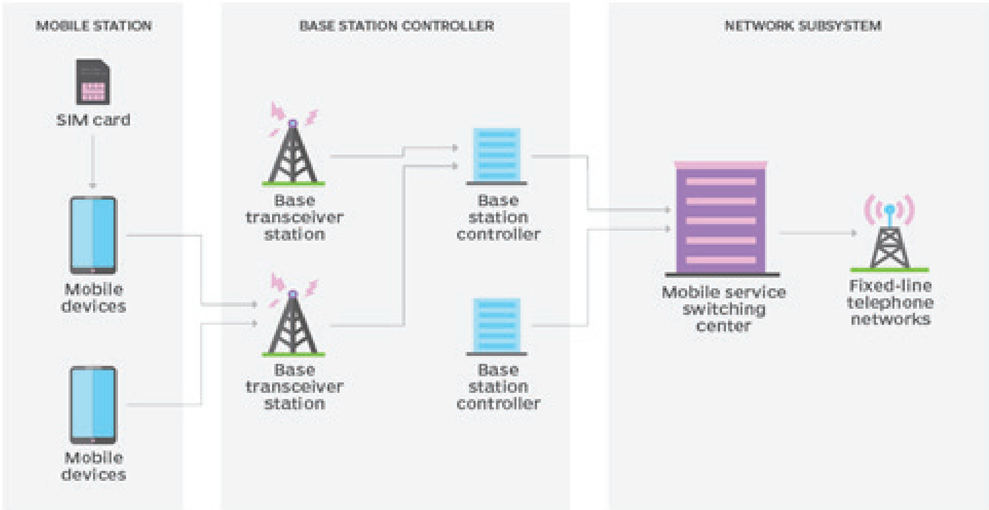


Fig. 1.2.8: UMTS Architecture

Previously, cellular telephone systems were mainly circuit-switched, meaning connections were always dependent on circuit availability. A packet-switched connection uses the Internet Protocol (I.P.), meaning that a virtual connection is always available to any end point in the network.

UMTS also makes it possible to provide new services like alternative billing methods or calling plans. For example, users can now choose pay-per-bit, pay-per-session, flat rate, or asymmetric bandwidth options. The higher bandwidth of UMTS enables other new services like video conferencing or IPTV. UMTS allows the Virtual Home Environment (V.H.E.) to fully develop, where a roaming user can have the same services either at home, in the office or in the field through a combination of transparent terrestrial and satellite connections.

The UMTS system uses the same core network as the GPRS and an entirely new radio interface. The new radio network in UMTS is called UTRAN (UMTS Terrestrial Radio Access Network) and is connected to the core network (C.N.) of GPRS via the Iu interface. The Iu is the UTRAN interface between the Radio network controller R.N.C. and C.N.

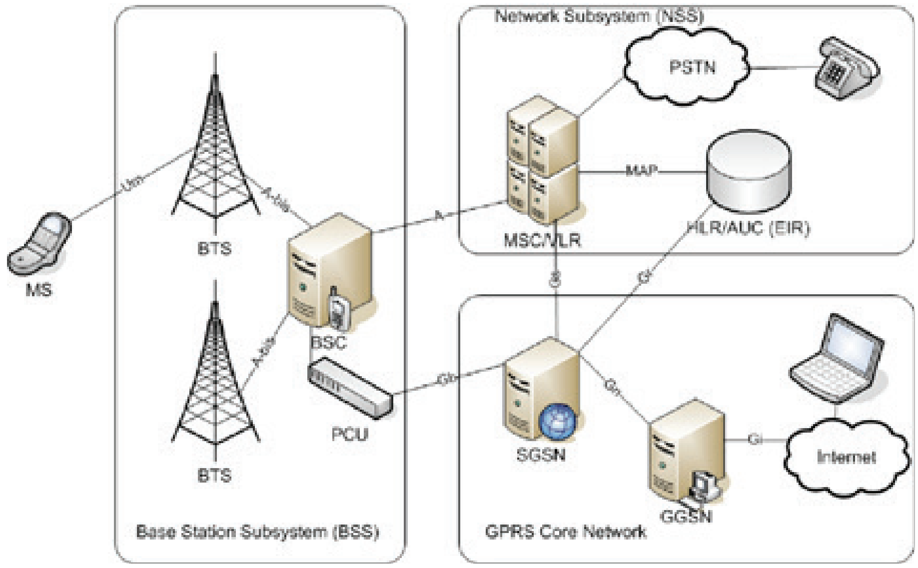


Fig. 1.2.9: UNTS Architecture Evolution

It gives transmission of content, digitised voice, video and multimedia. It gives tall transmission capacity to portable operators. It gives a tall information rate of 2Mbps. UMTS uses Wideband CDMA – WCDMA – as the radio transmission standard. It employs a 5 MHz channel bandwidth which enables it to carry over 100 simultaneous voice calls, or it is able to carry data at speeds up to 2 Mbps in its original format.

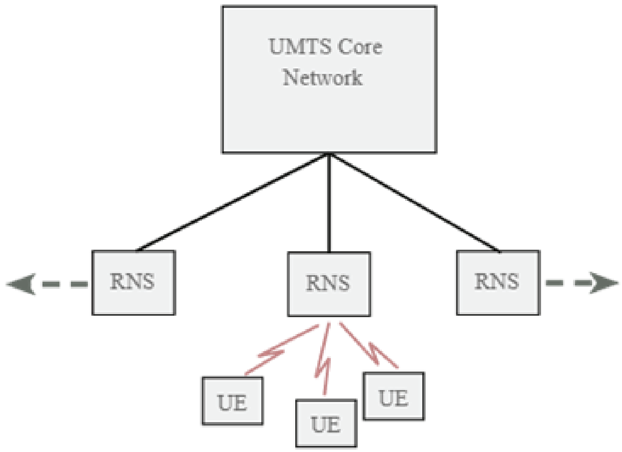


Fig. 1.2.10: UMTS Network Architecture

The UMTS network architecture can be divided into three main elements:

- **User Equipment (U.E.):** User Equipment or U.E. is the name given to what was previously termed the mobile or cellphone. The new name was chosen because of the considerably greater functionality that the U.E. could have. It could also be anything from a mobile phone used for talking to a data terminal attached to a computer with no voice capability.
- **Radio Network Subsystem (R.N.S.):** The R.N.S., also known as the UMTS Radio Access Network, UTRAN, is the equivalent of the previous Base Station Subsystem or B.S.S. in GSM. It provides and manages the air interface for the overall network.
- **Core Network:** The core network provides all the central processing and management for the system. It is the equivalent of the GSM Network Switching Subsystem or N.S.S. The core network is then the overall entity that interfaces to external networks, including the public phone network and other cellular telecommunications networks.

There are a number of elements within the U.E. that can be described separately:

R.F. circuitry: The R.F. areas handle all signal elements for the receiver and transmitter. One of the major challenges for the R.F. power amplifier was to reduce power consumption. The form of modulation used for W-CDMA requires the use of a linear amplifier, and these inherently take more current than non-linear amplifiers, which can be used for modulation on GSM. Accordingly, to maintain battery life, measures were introduced into many of the designs to ensure optimum efficiency.

Baseband processing: Baseband signal processing consists mainly of digital circuitry, and this is considered GSM. Accordingly, to maintain battery life, measures were introduced into many of the designs to ensure optimum efficiency.

Battery: While current consumption has been minimised as far as possible within the circuitry of the phone, there has been an increase in the current drain on the battery. With users expecting the same lifetime between charging batteries as experienced on the previous generation phones, this has necessitated the use of new and improved battery technology. Now Lithium Ion (Li-ion) batteries are used. These phones remain small and relatively light while still retaining or improving the overall life between charges.

Universal Subscriber Identity Module, USIM: The U.E. also contains a SIM card, although, in the case of UMTS, it is termed a USIM (Universal Subscriber Identity Module). This is a more advanced version of the SIM card used in GSM and other systems but embodies the same types of information. It contains the International Mobile Subscriber Identity number (IMSI) as well as the Mobile Station International ISDN Number (MSISDN).

Other information that the USIM holds includes the preferred language to enable the correct language information to be displayed, especially when roaming and a list of preferred and prohibited Public Land Mobile Network (PLMN).

The USIM also contains a short message storage area that allows messages to stay with the user even when the phone is changed. Similarly, "phone book" numbers and call information of the numbers of incoming and outgoing calls are stored. The U.E. can take various forms, although the most common format is still a version of a "mobile phone" with many data capabilities.

Radio Network Control

The UMTS Radio Access Network (UTRAN) is similar to B.S.S. in GSM. The R.N.C. is the governing element in the UMTS Radio Access Network (UTRAN) and controls the node B.S. connected to it. The function of R.N.C. is to manage Radio resources, mobility and encryption of the data before it is sent to and from the mobile.

This 3G UMTS / WCDMA network section interfaces to the U.E. and the core network. The overall radio access network, i.e., collectively, all the Radio Network Subsystems, is known as the UTRAN UMTS Radio Access Network.

The UMTS core network may be split into two different areas:

- **Circuit-switched elements:** These elements are primarily based on the GSM network entities and carry data in a circuit-switched manner, i.e., a permanent channel for the duration of the call.
- **Packet-switched elements:** These are designed to carry packet data. This enables much higher network usage as the capacity can be shared, and data is carried as packets which are routed according to their destination. Some network elements, particularly those associated with registration, are shared by both domains and operate in the same way they did with GSM.

Circuit-switched elements: The circuit-switched elements of the UMTS core network architecture include the following network entities:

- **Mobile switching centre (M.S.C.):** This is essentially the same as that within GSM, and it manages the circuit-switched calls under way.
- **Gateway M.S.C. (GMSC):** This is effectively the interface to the external networks.

Packet-switched elements: The packet-switched elements of the 3G UMTS core network architecture include the following network entities:

- **Serving GPRS Support Node (SGSN):** As the name implies, this entity was first developed when GPRS was introduced, and its use has been carried over into the UMTS network architecture. The SGSN provides a number of functions within the UMTS network architecture.
- **Mobility Management:** When a U.E. attaches to the Packet Switched domain of the UMTS Core Network, the SGSN generates MM information based on the mobile's current location.

- **Session Management:** The SGSN manages the data sessions, providing the required service quality and managing what is termed the PDP (Packet Data Protocol) contexts, i.e. the pipes over which the data is sent.
- **Interaction with other areas of the network:** The SGSN is able to manage its elements within the network only by communicating with other areas of the network, e.g. M.S.C. and other circuit-switched areas.
- **Billing:** The SGSN is also responsible for billing. It achieves this by monitoring user data flow across the GPRS network. The SGSN generates C.D.R.s (Call Detail Records) before being transferred to the charging entities (Charging Gateway Function, C.G.F.).
- **Gateway GPRS Support Node (GGSN):** Like the SGSN, this entity was also first introduced into the GPRS network. The GGSN is the central element within the UMTS packet switched network. It handles inter-working between the UMTS packet switched network and external packet switched networks and can be considered a very sophisticated router. In operation, when the GGSN receives data addressed to a specific user, it checks if the user is active and then forwards the data to the SGSN serving the particular U.E.

Shared Elements

The shared elements of the 3G UMTS core network architecture include the following network entities:

- **Home Location Register (H.L.R.):** This database contains all the administrative information about each subscriber, along with their last known location. In this way, the UMTS network is able to route calls to the relevant R.N.C./Node B. When a user switches on their U.E., it registers with the network. From this, it is possible to determine which Node B it communicates with so that incoming calls can be routed appropriately. Even when the U.E. is not active (but switched on), it re-registers periodically to ensure that the network (H.L.R.) is aware of its latest position with its current or last known location on the network.
- **Equipment Identity Register (EIR):** The EIR is the entity that decides whether a given U.E. equipment may be allowed onto the network. Each U.E. has a number known as the International Mobile Equipment Identity. This number, as mentioned above, is installed in the equipment and is checked by the network during registration.
- **Authentication centre (AuC):** The AuC is a protected database with the secret key in the user's USIM card.

1.2.5 LTE (Long-Term Evolution)

LTE is a fourth-generation (4G) wireless standard that provides increased network capacity and speed for cellphones and other cellular devices compared with third-generation (3G) technology.

Long-Term Evolution (LTE) is a standard for wireless broadband communication for mobile devices and data terminals, based on the GSM/EDGE and UMTS/HSPA standards. It improves those standards' capacity and speed by using a different radio interface and core network improvements.

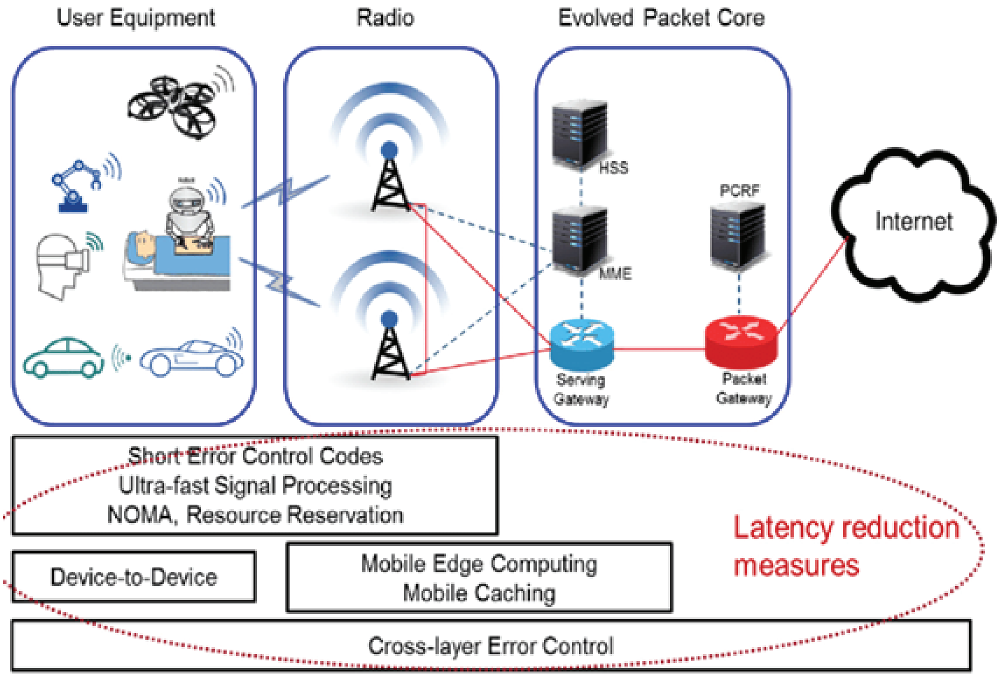


Fig. 1.2.11: Architecture of 4G LTE technology

LTE is comprised of the following three main components:

- The User Equipment (U.E.)
- The Evolved UMTS Terrestrial Radio Access Network (E-UTRAN)
- The Evolved Packet Core (E.P.C.)

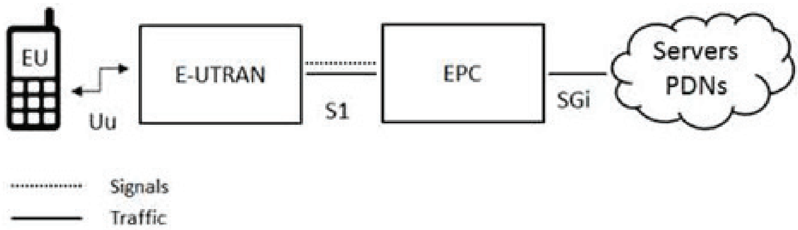


Fig. 1.2.12: Components of LTE Network Architecture

The evolved packet core communicates with packet data networks in the outside world, such as the internet, private corporate networks or the I.P. multimedia subsystem. The interfaces between the different parts of the system are denoted Uu, S1 and Sgi, as shown above.

The User Equipment (U.E.)

The internal architecture of the user equipment for LTE is identical to the one used by UMTS and GSM, which is actually Mobile Equipment (M.E.). The mobile equipment comprised of the following important modules:

- Mobile Termination (M.T.): This handles all the communication functions
- Terminal Equipment (T.E.): This terminates the data streams
- Universal Integrated Circuit Card (UICC): This is also known as the SIM card for LTE equipment. It runs an application known as the Universal Subscriber Identity Module (USIM)

A USIM stores user-specific data, very similar to a 3G SIM card. This keeps the user's phone number, home network identity, security keys, etc.

The E-UTRAN (The access network)

The architecture of evolved UMTS Terrestrial Radio Access Network (E-UTRAN) has been illustrated below.

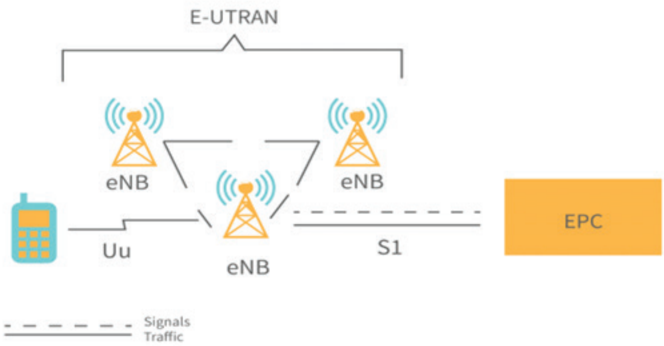


Fig. 1.2.13: LTE network architecture over E-UTRAN

The E-UTRAN handles the radio communications between the mobile and the evolved packet core and just has one component, the evolved base stations, called eNodeB or eNB. Each eNB is a base station that controls the mobiles in one or more cells. The base station that is communicating with mobile is known as its serving eNB.

LTE Mobile communicates with just one base station and one cell at a time, and there are following two main functions supported by eNB:

- The eBN sends and receives radio transmissions to all the mobiles using the analogue and digital signal processing functions of the LTE air interface.
- The eNB controls the low-level operation of all its mobiles by sending them signalling messages such as handover commands.

Each eBN connects with the E.P.C. by means of the S1 interface, and it can also be connected to nearby base stations by the X2 interface, which is mainly used for signalling and packet forwarding during handover.

A home eNB (HeNB) is a base station that a user has purchased to provide femtocell coverage within the home. A home eNB belongs to a closed subscriber group (C.S.G.) and can only be accessed by mobiles with a USIM that also belongs to the closed subscriber group.

Evolved Packet Core (E.P.C.) (The core network)

The architecture of Evolved Packet Core (E.P.C.) has been illustrated below. A few more components have not been shown in the diagram to keep it simple. These components are the Earthquake and Tsunami Warning System (ETWS), the Equipment Identity Register (EIR) and Policy Control and Charging Rules Function (PCRF).

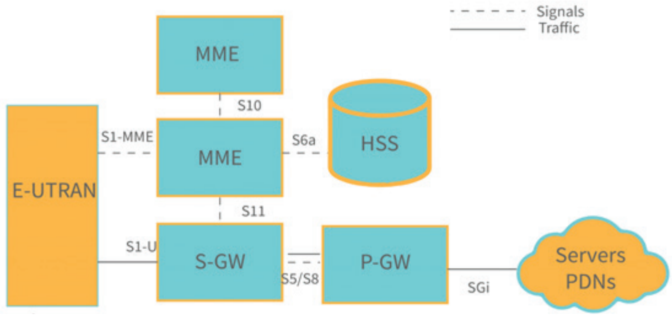


Fig. 1.2.14: The core network

Below is a brief description of each of the components shown in the above architecture:

- The Home Subscriber Server (H.S.S.) component has been carried forward from UMTS and GSM and is a central database that contains information about all the network operator's subscribers.
- The Packet Data Network (P.D.N.) Gateway (P-GW) communicates with the outside world, i.e., Packet data networks P.D.N., using the Sgi interface. Each packet data network is identified by an access point name (A.P.N.). The P.D.N. gateway has the same role as the GPRS support node (GGSN) and the serving GPRS support node (SGSN) with UMTS and GSM.
- The serving gateway (S-GW) acts as a router and forwards data between the base station and the P.D.N. gateway.
- The mobility management entity (M.M.E.) controls the mobile's high-level operation by signalling messages and the Home Subscriber Server (H.S.S.).
- The Policy Control and Charging Rules Function (PCRF) is a component which is not shown in the above diagram, but it is responsible for policy control decision-making, as well as for controlling the flow-based charging functionalities in the Policy Control Enforcement Function (PCEF), which resides in the P-GW.

The interface between the serving and P.D.N. gateways is called S5/S8. This has two slightly different implementations, namely S5 if the two devices are in the same network and S8 if they are in different networks.

Functional split between the E-UTRAN and the E.P.C.

The following diagram shows the functional split between the E-UTRAN and the E.P.C. for an LTE network:

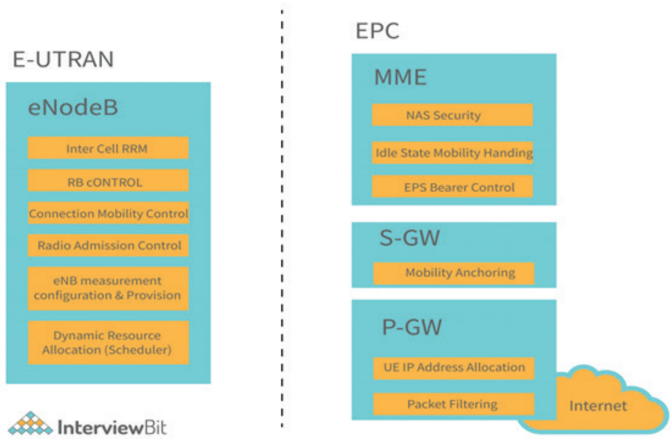


Fig. 1.2.15: Functional difference between the E-UTRAN and the E.P.C.

1.2.6 VoLTE

VoLTE (voice over LTE) is the foundation for evolving mobile voice and communication services for packet switched 4G, Wi-Fi and 5G networks. It is the mainstream mobile network technology for enabling globally interoperable voice and communication services using I.P. Multimedia Subsystem (I.M.S.).

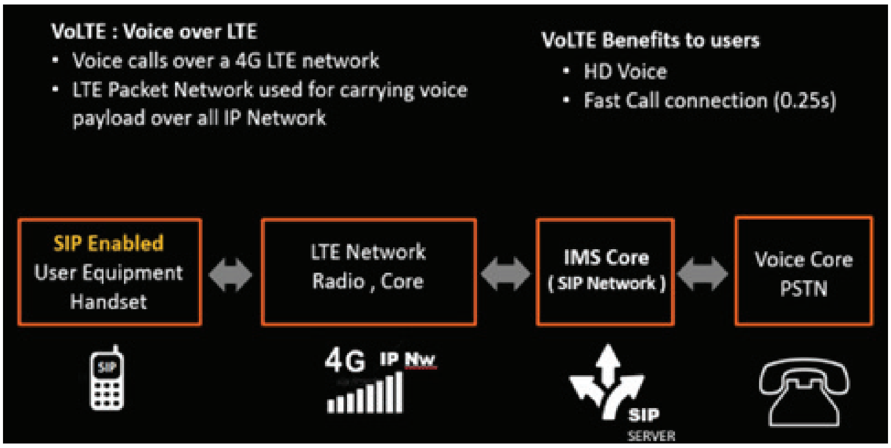


Fig. 1.2.16: VoLTE Architecture

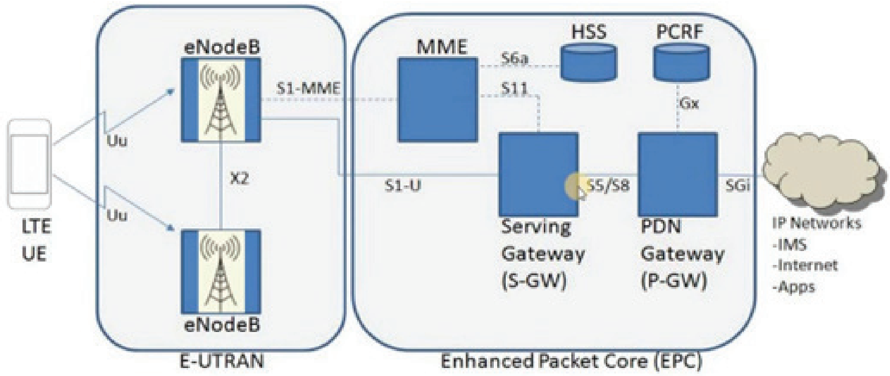


Fig. 1.2.17: LTE Architecture

The idea of I.M.S. is old, but after its deployment with LTE, users and operators can harness the true power of I.M.S. I.M.S. – I.P. Multimedia Subsystem is a standalone system which resides out of the LTE network and is connected to P.D.N. Gateway through the Sgi interface.

The E.P.C. has three main functional elements:

- The first one is Mobility Management Entity (M.M.E.). M.M.E. is the single most control point in the E.P.C. and is responsible for most of the control plane functions.
- The second on the list is Serving Gateway (S-GW). All I.P. packets in uplink and downlink flow through S-GW. S-GW is also responsible for handling handovers.
- The last on the list is P-GW or P.D.N. Gateway. P-GW allocates I.P. addresses to U.E.s. It also provides interfaces to the internet and I.M.S.

User Equipment

U.E. is a mobile terminal authorised to be used in an LTE network. U.E. may be a smartphone, tablet or other communication devices.

An I.M.S. powered U.E. has two main components.

- Universal Integrated Circuit Card (UICC)
- Session Initiation Protocol User Agent (S.I.P. UA)

Universal Integrated Circuit (UICC)

Each U.E. must contain one UICC, and each UICC may have one or more of the following modules:

- Subscriber Identity Module (SIM): SIM identity information used by a GSM network.
- UMTS Subscriber Identity Module (USIM): USIM information used by a UMTS or LTE network.
- CDMA Subscriber Identity Module (CSIM) or Reusable Identification Module (R-UIM). CDMA network uses this identity information
- I.P. Multimedia Services Identity Module (ISIM): I.M.S. subsystem uses IMSI identity information.

Let's look into ISIM, which is important when U.E. wants to use I.M.S. resources in the network. ISIM contains the following:

- I.P. Multimedia Private Identity (IMPI): IMPI is a global identity allocated by the home network. IMPI contains the home operator's domain information.
- Home operator's domain name
- I.P. Multimedia Public Identity (IMPU): IMPU acts like a telephone number. It can either be a SIP URI (sip:@:) or a tel URI.
- Secret Key: This long secret key is used for user authentication and S.I.P. registration.

S.I.P. User Agent (SIP-UA)

S.I.P. User Agent resides in the U.E. to send and receive S.I.P. messages. SIP-UA provides basic telephony functionality. It can act in two different roles:

- User Agent Client (U.A.C.): As a client to send S.I.P. request
- User Agent Server (U.A.S.): As a server to receive requests and send the response

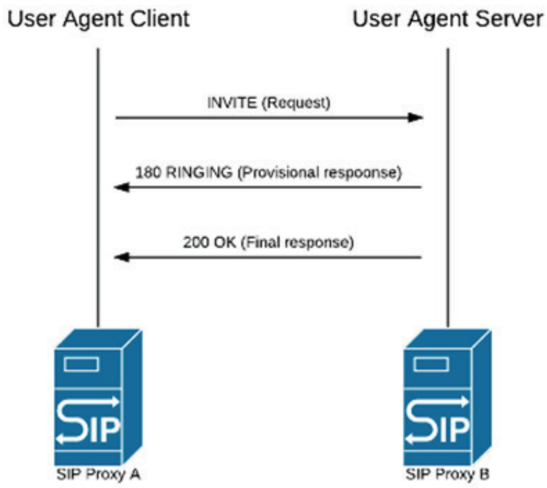


Fig. 1.2.18: Functioning of SIP server

Evolved Packet Core

SGW (Serving Gateway): The SGW node handles the user data traffic but isn't responsible for the signalling data used. It transports I.P. data from U.E.'s to the LTE Core Network. The SGW also routes incoming and outgoing I.P. packets for better system collaboration and serves as an anchor for the U.E. when it moves from one eNodeB to another.

PGW (P.D.N. Gateway): PGW is the network node that connects the E.P.C. to external I.P. networks. What the PGW does is that it routes packets to and from external I.P. networks. Beyond that, it also allocates an I.P. address to all U.E.s and enforces different policies regarding I.P. user traffic, such as packet filtering.

Policy and Charging Rule Function (PCRF): The PCRF determines the allowed traffic types in real-time. It also checks how to account for the traffic. Operators use this information for billing purposes. Based on requests for I.M.S. services, the PCRF also initiates the appropriate bearers.

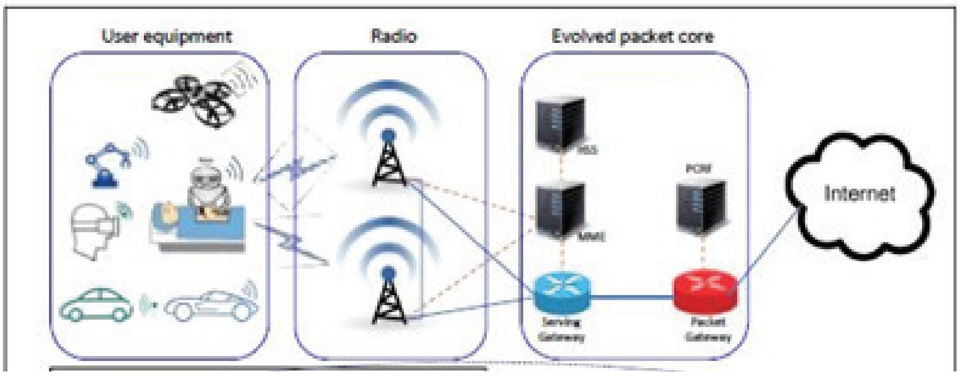


Fig. 1.2.19: PGW and SGW

UNIT 1.3: Types of Channels in GSM/UMTS/LTE

Unit Objectives

By the end of this unit, the participants will be able to:

1. List the type of channels in GSM/UMTS/LTE
2. Identify physical and logical channels

1.3.1 GSM Channel Classification

GSM uses a variety of 'channels' in which the data is carried. In GSM, these channels are separated into physical channels and logical channels. The Physical channels are determined by the timeslot, whereas the logical channels are determined by the information carried within the physical channel.

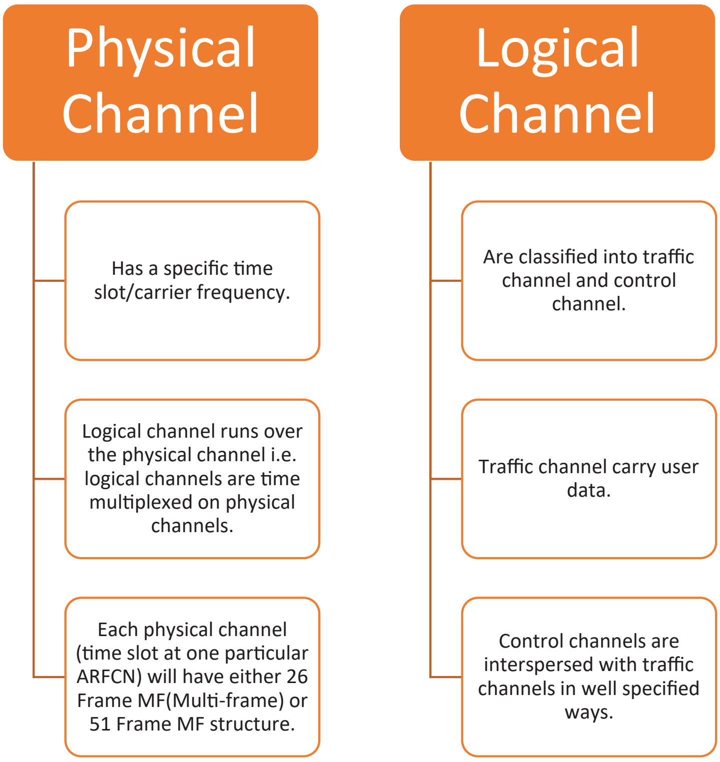


Fig.1.3.1: Channels in GSM

Several recurring timeslots on a carrier constitute a physical channel. Different logical channels then use these to transfer information. These channels may either be used for user data (payload) or signalling to enable the system to operate correctly.

The channels may also be divided into common and dedicated channels. The forward common channels are used for paging to inform a mobile of an incoming call, responding to channel requests, and broadcasting bulletin board information. The return common channel is a random-access channel used by the mobile to request channel resources before timing information is conveyed by the B.S.S.

The dedicated channels are of two main types: those used for signalling and those used for traffic. The signalling channels are used to maintain the call and enable call set up, provide facilities such as handover when the call is in progress, and finally terminate the call. The traffic channels handle the actual payload.

The following logical channels are defined in GSM

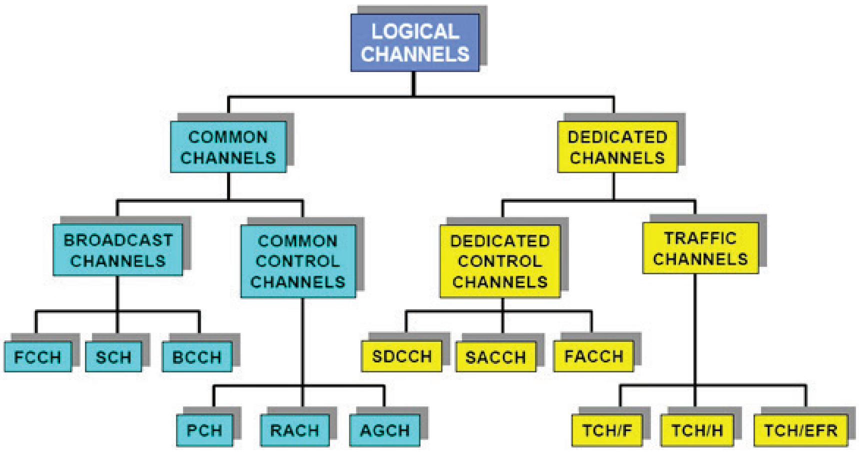


Fig 1.3.2 Logical channels classification

The following table lists the various channels along with their descriptions:

Interface	Description
BCH	
Broadcast Control Channel (BCCH)	BCCH is the most important control channel. It is transmitted/broadcasted to all the mobiles in the cell. It is a downlink channel and carries System Information (SI) messages to mobiles. It is transmitted in 51 frame MF structure in the frame next to SCH on TSO. Four consecutive TDMA frames are needed to carry complete BCCH information. Base stations are continuously broadcasting critical system information messages. These messages help a mobile determine which GSM cell it can camp on to access the GSM network.
Frequency Control Channel (FCCH)	FCCH is provided in the GSM frame to facilitate BTS and GSM mobile synchronisation. It is a downlink channel that carries a continuous wave signal. These signals enable mobile to find the frequency offset between BTS and MS. GSM FCCH uses 51 Frame MF structure in which it occupies the first time slot, TSO, and repeats transmission once in 10 TDMA frames.
Synchronization Channel (SCH)	Once a mobile is a frequency synchronized with BTS, it needs to be time synchronized. The SCH helps to facilitate time synchronization of the mobile with the GSM frame structure. SCH is transmitted by BTS, a downlink channel, and uses a synchronization burst (SB). It carries a frame number and Base Station Identity Code (BSIC), which helps identify the Base station in the GSM network.
A network uses CCCHs to convey information and provide access to Mobile Subscribers (MS)	
Paging Channel (PGH)	The network uses PCH to page or alert a mobile for mobile terminated calls from another calling mobile. Mobile use it in idle mode to continuously page and check for its address.
Randon Access Channel (RACH)	The mobile uses RACH to access the GSM network during call set-up time. The RACH information is mapped using Access burst. Whenever mobile wants to make a MO call, it schedules the RACH.

Interface	Description
Access Grant Channel (AGCH)	AGCH is a downlink channel that carries information which helps a mobile determine whether access to the network has been allowed or denied. It provides information to a mobile regarding the TCH/SDCCH channels to use during communication with the network.
Dedicated Control Channel (DCCH)	
Standalone Dedicated Control Channel (SDCCH)	SDCCH is a signalling channel that exists between GSM Mobile and GSM BTS. SDCCH exists independent of the traffic channel (TCH).
Fast Associated Control Channel (FACCH)	The FACCH exchanges information between GSM Mobile Station (MS) and Base Transceiver Station (BTS) more quickly than possible with SACCH. FACCH information message can easily be transmitted in 20 ms duration, as used by traffic channel (TCH).
Slow Associated Control Channel (SACCH)	Slow Associated Control Channel is called "associated" as this channel is always associated with either TCH or SDCCH. It maps on the same physical channel (TO, FO) as TCH/SDCCH. TO is the time slot, and FO is frequency. SACCH is always available between Mobile and Base station (BTS) in GSM when a dedicated traffic link is active. In the downlink, SACCH is used to convey power level control instructions and timing advance information to the GSM mobile. In the uplink, SACCH carries received signal strength, TCH quality information and measurement report of neighbouring cells etc.

Table 1.3.1: Types of channels

GSM Traffic Channels

GSM has two types of traffic channels, TCH/FS and TCH/HS and is used both in the uplink and downlink.

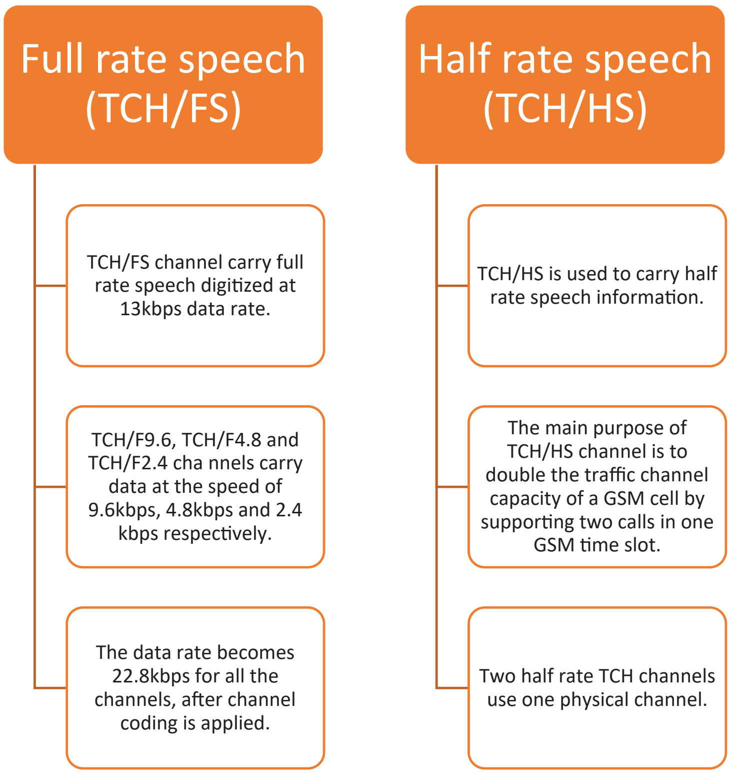


Fig. 1.3.3: Types of traffic channels in GSM

1.3.2 Basic Logic channels during Call Setup

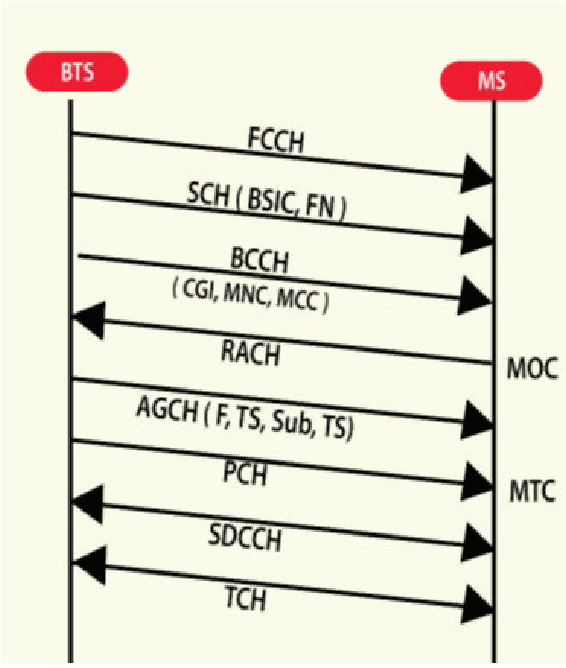


Fig. 1.3.4: Basic logical channels during call setup

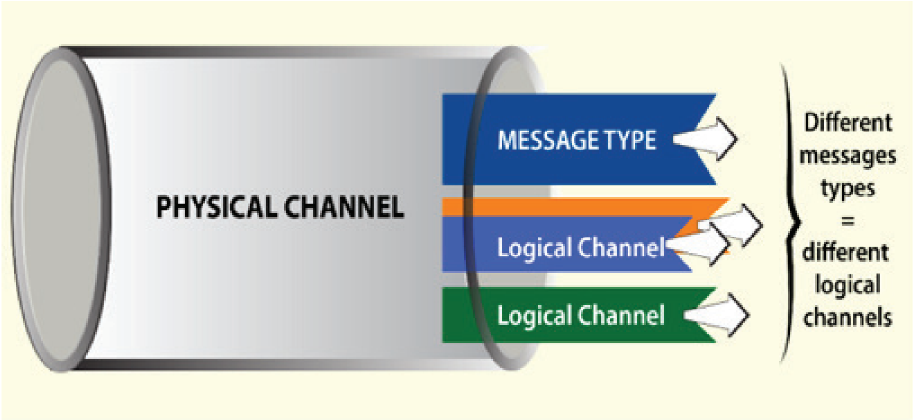


Fig. 1.3.5: Flow of Information through Logic Channels

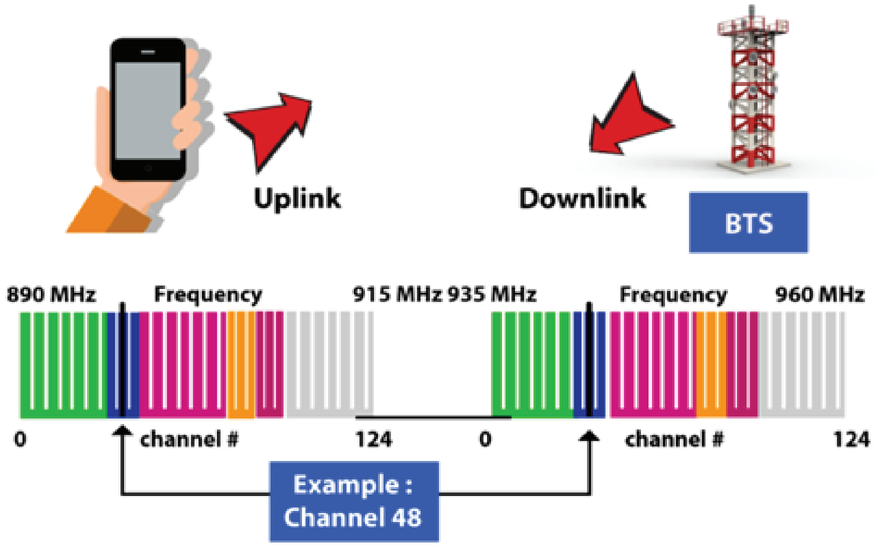
1.3.3 GSM Channel Mapping

The following steps describe the channel mapping process in GSM:

When the MS is turned on, it listens to the FCCH to sync to the carrier frequency.
→ The MS listens to the SCH to get information on the TDMA frame structure.
→ The MS then listens to the BCCH to get information like location area, Max allowed output power and neighbouring cells.
→ The MS periodically listens to the PCH to detect if someone is trying to call it.
→ If the MS hears a page, it uses the RACH to inquire for access to the system to respond to the incoming call.
→ The system gives access using the AGCH.
→ The system uses the AGCH to inform the MS which SDCCH to use to complete the Call Setup.
→ When the MS receives the SDCCH, it also gets a SACCH. The system uses it to regulate the output power of the MS and produces advance Information.
→ The MS is provided with a TCH to use by the SDCCH. The MS tunes itself to it during the call.
→ During a call, if a handover is necessary (to a neighbouring cell), the FACCH is used to exchange the information.

Fig. 1.3.6: GSM Channel Mapping

The following figure shows the propagation of information (frequency) in GSM architecture



1.3.7: Propagation of information (frequency) in GSM architecture

1.3.4 Channel Classification in UMTS

UMTS channel structures

UMTS uses CDMA techniques (as WCDMA) as its multiple access technologies, but it additionally uses time division techniques with a slot and frame structure to provide the full channel structure. The channels carried are categorised into three:

- Logical channels (RLC layer): The logical channels define the way in which the data will be transferred
- Physical channels (PHY layer): The physical channels carry the payload data and govern the physical characteristics of the signal
- Transport channels (MAC layer): The 3G transport channels, along with the logical channel, again defines the way in which the data is transferred

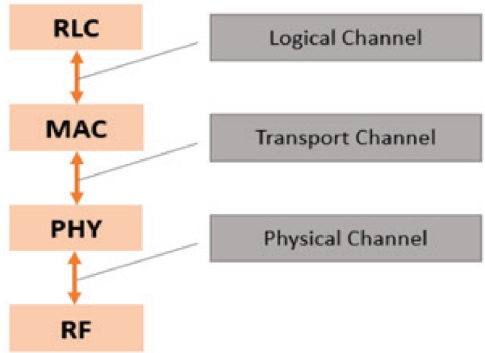


Fig. 1.3.8: Types of UMTS channels

The channels are organised such that the logical channels are related to what is transported, whereas the physical layer transport channels deal with how and with what characteristics. The M.A.C. layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services.

UMTS Logical Channels

The following figure shows the types of UMTS logical channels:

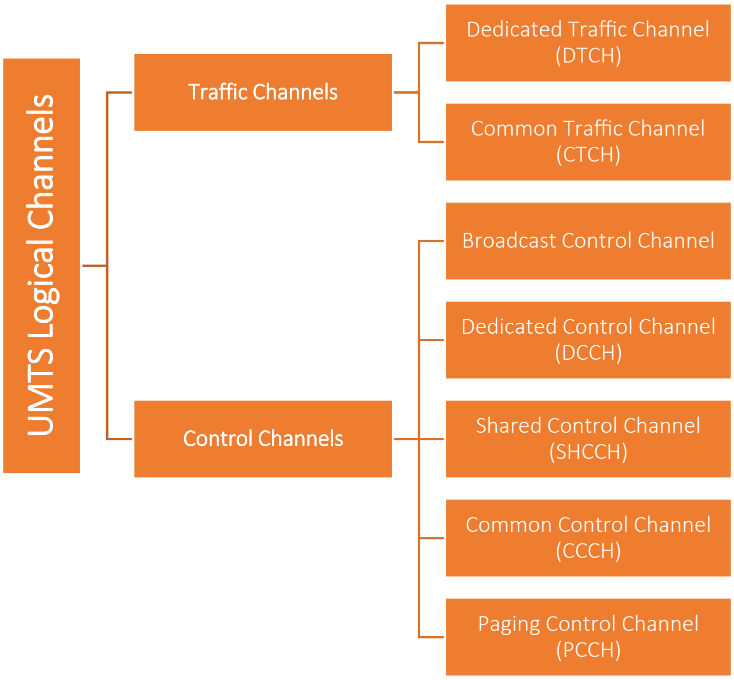


Fig. 1.3.9: Types of UMTS logical channels

The following table shows the functions and the direction of different UMTS/WCDMA logical channels:

UMTS/WCDMA Logical Channel	Function	Direction	Duplex Mode
Dedicated traffic channel (DTCH)	carry user plane data (speech/packet data)	Uplink (UL)/Downlink (DL)	FDD/TDD
Dedicated control channel (DCCH)	carry signaling messages used for control operations	Uplink/Downlink	FDD/TDD
Shared control channel (SHCCH)	carry control messages	Uplink/Downlink	TDD
Common control channel (CCCH)	It is used to carry control messages	Uplink/Downlink	FDD/TDD
Common traffic			
Channel (CTCH)	It is used to carry user traffic (e.g., Cell broadcast SMS)	Downlink	FDD/TDD
Paging control channel (PCCH)	It is used to carry paging messages directed towards UE	Downlink	FDD/TDD
Broadcast control channel (BCCH)	It is used to carry broadcast messages towards UE	Downlink	FDD/TDD

Table 1.3.2: Logical Channels

UMTS Transport Channels

The UMTS transport channels include:

- Dedicated Transport Channel (D.C.H.) (Up and downlink). This is used to transfer data to a particular U.E. Each U.E. has its own D.C.H. in each direction.
- Broadcast Channel (B.C.H.) (downlink). This channel broadcasts information to the U.E.s in the cell to enable them to identify the network and the cell.
- Forward Access Channel (FACH) (down link). This channel carries data or information to the U.E.s registered on the system. There may be more than one FACH per cell as they may carry packet data.
- Paging Channel (PCH) (downlink). This channel carries messages that alert the U.E. to incoming calls, SMS messages, data sessions or required maintenance such as re-registration.
- Random Access Channel (RACH) (uplink). This channel carries requests for service from U.E.s trying to access the system
- Uplink Common Packet Channel (CPCH) (uplink). This channel provides additional capability beyond that of the RACH and for fast power control.
- Downlink Shared Channel (DSCH) (downlink). This channel can be shared by several users and is used for data that is “bursty” in nature, such as that obtained from web browsing etc.

The following table shows the functions and the direction of different UMTS/WCDMA transport channels:

UMTS/WCDMA Transport Channel	Function	Direction
Random access channel (RACH)	It is used for initial access of the network by UE	Uplink
Common packet channel (CPCH)	It is used as contention channel for bursty data	Uplink
Forward access channel (FACH)	It is used to transfer user data/control signaling messages	Downlink
Downlink shared channel (DSCH)	It is used as shared channel carrying dedicated user data/control messages in the downlink	Downlink
Uplink shared channel (USCH)	It is used as shared channel carrying dedicated user data/control messages in the uplink	Uplink
Broadcast channel (BCH)	Broadcast channel to all UEs in a cell	Downlink
Paging channel (PCH)	Broadcast of paging & notification messages, also allows UE to make use of sleep Mode	Downlink
Dedicated Channel (DCH)	It is used as dedicated channel to transfer traffic/control messages in both the direction	Uplink/Downlink

Table 1.3.3: Functions and the direction of different UMTS/WCDMA transport channels

UMTS Physical Channels

There are ten types of UMTS physical channels. The following figure shows the different types of UMTS Physical channels

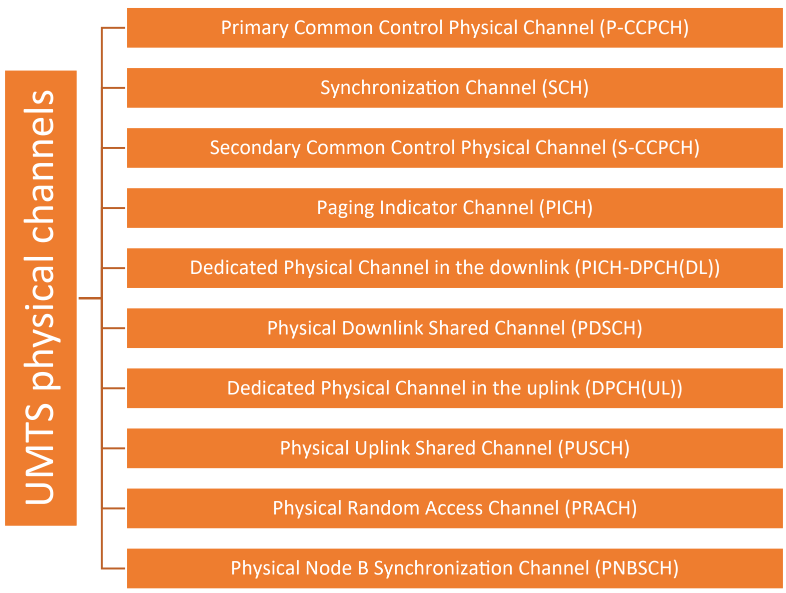


Fig. 1.3.10: Physical Channels

Mapping between Channels

The following figure shows the mapping between the three types of UMTS channels:

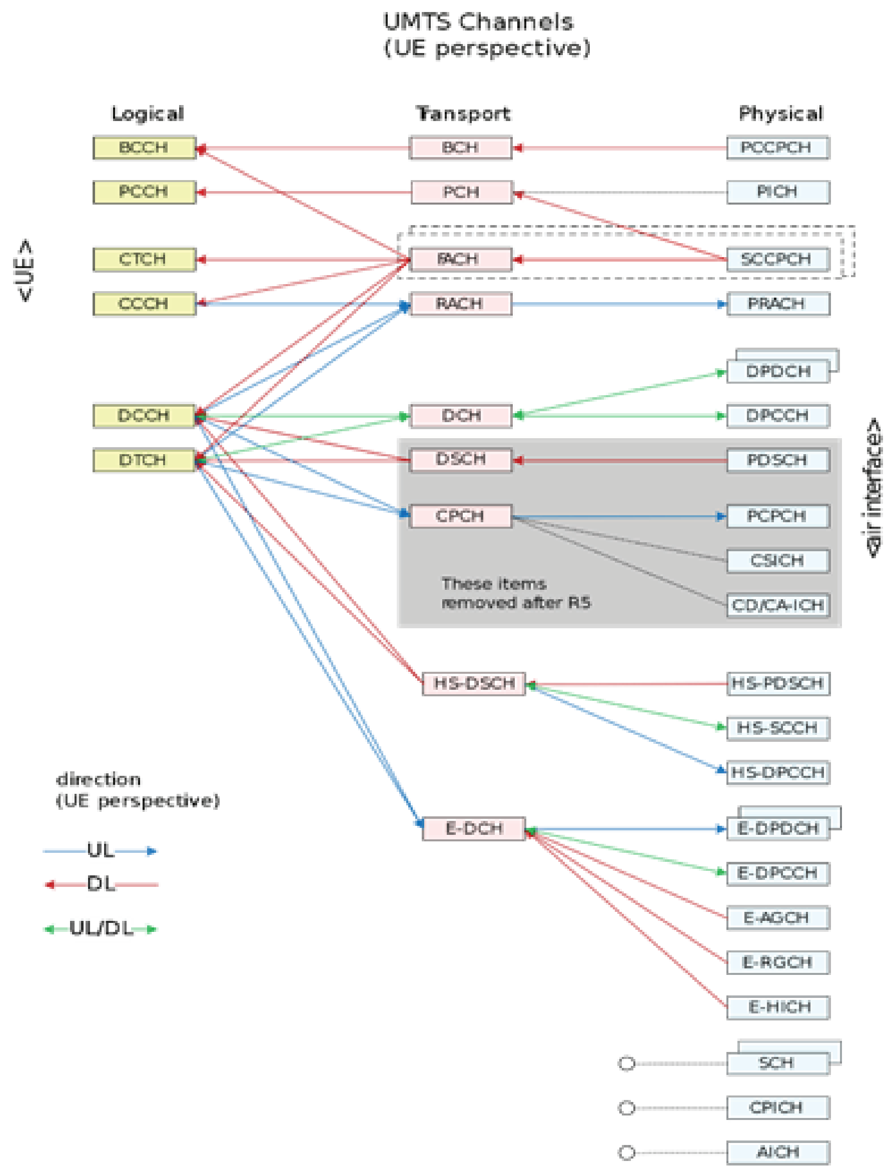


Fig 1.3.11 Mapping between UMTS Channels

1.3.5 Channels in LTE

Various data channels may be grouped into three categories:

- **Physical channels:** These are transmission channels that carry user data and control messages.
- **Logical channels:** Provide services for the Medium Access Control (M.A.C.) layer within the LTE protocol structure.
- **Transport channels:** The physical layer transport channels offer information transfer to Medium Access Control (M.A.C.) and higher layers.

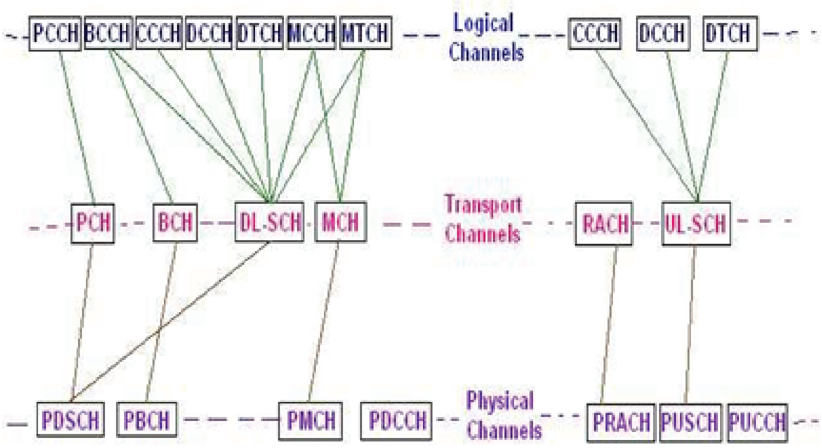


Fig 1.3.12 LTE Channel classification

LTE physical channels

The LTE physical channels vary between the uplink and the downlink as each has different requirements and operates in a different manner.

Downlink:

- **Physical Broadcast Channel (PBCH):** This physical channel carries system information for U.E.s required to access the network. It only carries what is termed Master Information Block, M.I.B., messages. The modulation scheme is always QPSK, and the information bits are coded and rate matched – the bits are then scrambled using a scrambling sequence specific to the cell to prevent confusion with data from other cells. The M.I.B. message on the PBCH is mapped onto the central 72 subcarriers or six central resource blocks regardless of the overall system bandwidth. A PBCH message is repeated every 40 ms, i.e. one T.T.I. of PBCH includes four radio frames. The PBCH transmissions have 14 information bits, 10 spare bits, and 16 C.R.C. bits.
- **Physical Control Format Indicator Channel (PCFICH):** As the name implies, the PCFICH informs the U.E. about the format of the signal being received. It indicates the number of OFDM symbols used for the PDCCHs, whether 1, 2, or 3. The information within the PCFICH is essential because the U.E. does not have prior information about the size of the control region. A PCFICH is transmitted on the first symbol of every sub-frame and carries a Control Format Indicator, CFI, field. The CFI contains a 32-bit code word that represents 1, 2, or 3. CFI 4 is reserved for possible future use. The PCFICH uses 32,2 block coding, which results in a 1/16 coding rate, and it always uses QPSK modulation to ensure robust reception.
- **Physical Downlink Control Channel (PDCCH):** The main purpose of this physical channel is to carry mainly scheduling information of different types:
  - Downlink resource scheduling
  - Uplink power control instructions
  - Uplink resource grant
  - Indication for paging or system information

The PDCCH contains a message known as the Downlink Control Information, DCI, which carries the control information for a particular U.E. or group of U.E.s. The DCI format has several different types, which are defined in different sizes. The different format types include: Type 0, 1, 1A, 1B, 1C, 1D, 2, 2A, 2B, 2C, 3, 3A, and 4.

- **Physical Hybrid A.R.Q. Indicator Channel (PHICH):** As the name implies, this channel is used to report the Hybrid A.R.Q. status. It carries the HARQ ACK/NACK signal indicating whether a transport block has been correctly received. The HARQ indicator is 1 bit long – "0" indicates A.C.K., and "1" indicates NACK.

  The PHICH is transmitted within the control region of the subframe and is typically only transmitted within the first symbol. If the radio link is poor, then the PHICH is extended to a number of symbols for robustness.

Uplink:

- **Physical Uplink Control Channel (PUCCH):** The Physical Uplink Control Channel, PUCCH, provides various control signalling requirements. Several PUCCH formats are defined to enable the channel to carry the required information in the most efficient format for the particular scenario encountered. It includes the ability to carry S.R.s, Scheduling Requests.
- **Physical Uplink Shared Channel (PUSCH):** This physical channel found on the LTE uplink is the Uplink counterpart of PDSCH
- **Physical Random-Access Channel (PRACH):** This uplink physical channel is used for random access functions. This is the only non-synchronised transmission that the U.E. can make within LTE. The downlink and uplink propagation delays are unknown when PRACH is used; therefore, they cannot be synchronised. The PRACH instance is made up of two sequences: a cyclic prefix and a guard period. The preamble sequence may be repeated to enable the eNodeB to decode the preamble when link conditions are poor.

LTE logical channels

The logical channels cover the data carried over the radio interface. The Service Access Point, SAP, between M.A.C. sublayer and the R.L.C. sublayer provides the logical channel.

- **Control channels:** These LTE control channels carry the control plane information:
  - Broadcast Control Channel (BCCH): This control channel provides system information to all mobile terminals connected to the eNodeB.
  - Paging Control Channel (PCCH): This control channel is used for paging information when searching units on a network.
  - Common Control Channel (CCCH): This channel is used for random access information, e.g. for actions including setting up a connection.
  - Multicast Control Channel (MCCH): This control channel is used for Information needed for multicast reception.
  - Dedicated Control Channel (DCCH): This control channel is used for carrying user-specific control information, e.g., for controlling actions including power control, handover, etc.
  - Traffic Channels: These LTE traffic channels carry the user-plane data.
    - **Dedicated Traffic Channel (DTCH):** This traffic channel is used to transmit user data.
    - **Multicast Traffic Channel (MTCH):** This channel is used to transmit multicast data.

LTE transport channels

The LTE transport channels vary between the uplink and the downlink as each has different requirements and operates in a different manner. Physical layer transport channels offer information transfer to medium access control (M.A.C.) and higher layers.

Downlink:

- **Broadcast Channel (B.C.H.):** The LTE transport channel maps to Broadcast Control Channel (BCCH)
- **Downlink Shared Channel (DL-SCH):** This transport channel is the main channel for downlink data transfer. It is used by many logical channels.
- **Paging Channel (P.C.H.):** To convey the PCCH
- **Multicast Channel (M.C.H.):** This transport channel is used to transmit MCCH information to set up multicast transmissions.

Uplink:

- **Uplink Shared Channel (UL-SCH):** This transport channel is the main channel for uplink data transfer. It is used by many logical channels.
- **Random Access Channel (RACH):** This is used for random access requirements. The basic concept of data channels is not new and has been used in previous generations of mobile telecom systems. The LTE channels bear many similarities to those of the previous generations, but the channels are tailored to LTE and build on functionality.

The LTE channels for data transport enable the system to operate efficiently and effectively by ensuring that the data is partitioned and also routed to the required destination as easily as possible.

Mapping between LTE Channels

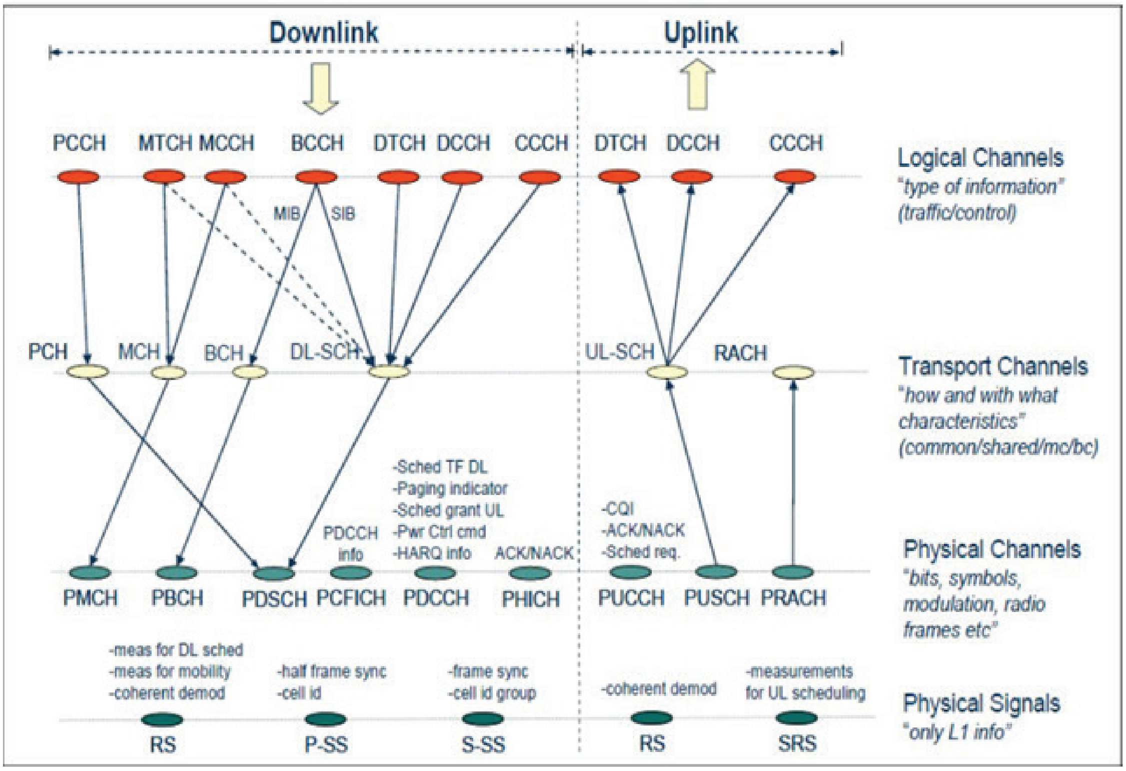


Fig. 1.3.13: Mapping between LTE channels

UNIT 1.4: Examine Parameters Common to 2G/3G/4G

Unit Objectives

By the end of this unit, the participants will be able to:

1. Analyse the key site parameters

1.4.1 Key Site Parameters

There are certain parameters which are common to 2G/ 3G/4G. These key parameters are as follows:

- Coverage analysis
- Overshooting / Pollution analysis
- Neighbouring site analysis
- Network KPI analysis
- Call drop analysis
- Delay analysis

Coverage analysis

Radio planning for every different existing standard has become a crucial aspect of optimising the performance of the physical layer and minimising interferences. Radio propagation models were designed to evaluate the coverage of different frequency ranges from different areas. An analysis of the 2G and 3G coverage is carried out based on the information about the base station parameters shared by a local mobile operator. Telecom software is used to measure the coverage analysis, and reports are generated based on the findings. A conclusion is drawn based on the measured and simulated data discrepancies. Based on the conclusion data, propagation model sheets for different areas are calculated, and the frequencies are measured to provide the most suitable ranges.

Overshooting/Pollution analysis

Overshooting refers to the overlapping of signals; in the case of Overshooting, one propagation comes from the nearer server, and the other comes from the further server. The above phenomenon is also referred to as Cross Coverage in LTE and Pollution in the case of 3G. To optimise the issue, the following steps are performed:

- Verify the RSCP coverage signal by Primary Scrambling Code (P.S.C.) in 3G networks, using a post-processing tool after the driving test.
- Identify the server, which is far respect to the other servers, and then reduce the electrical tilt, and mechanical tilt or give re-direction to the azimuth from the polluter or offender in 3G/LTE. 44 Participant Handbook

Neighbouring site analysis

The MS maintains a list of frequencies of neighbouring cells. This information enables the M.S. to perform and report measurements, and eventually, in cell reselection and handover.

Scrambling Code Optimisation

One of the primary tasks to undertake while planning a 3G network is how to allocate the Primary Scrambling Codes (P.S.C.) over all the cells in the network. S.C. planning is used in a greenfield network to resist code clashes. The scope of Scrambling Code planning is either to generate a new plan for the entire network. The benefits of the Scrambling Code are as follows:

- Reduces dropped calls rate by negating non-unique cell identification
- Reduces Radio link addition failures
- Reduces interference level by omitting duplicate S.C. in small geographical areas
- Different carriers are either treated as isolated networks or use the same scrambling code for all carriers in one sector to decrease network complexity

I.P. Network

Internet Protocol Telephony or I.P. Telephony refers to the technologies that use the Internet Protocol's packet-switched connections to exchange voice, fax, and other forms of information.

- The packet is given enough information to be transported to the destination
- The packet is transported from one node of the network to the other toward the destination
- The combination of TCP/IP is commonly referred to while talking about the delivery of data on the Internet

The following figure shows a typical I.P. network:

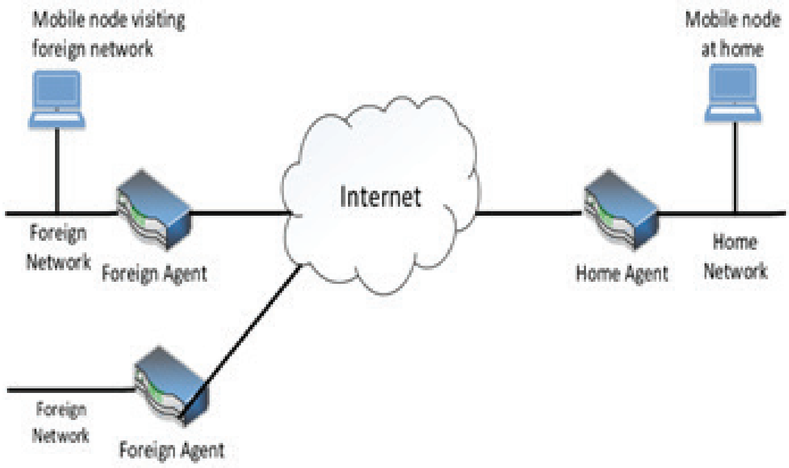


Fig. 1.4.1: IP Network

KPI Analysis

KPI stands for Key Performance Indicator. KPI analysis helps the drive test engineers to gauge the issues and find suitable solutions. It is more like a quality check for the drive test parameters.

The performance of the network is analysed in terms of KPIs related to voice quality (based on statistics) created by the radio network. The best way to generate these performance statistics is to drive test and network management systems. From the point of view of the operators, the most important KPIs are:

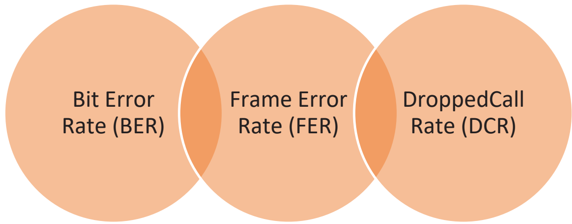


Fig. 1.4.2: Important KPIs

Bit Error Rate (BER) and Frame Error rate (F.E.R.): The BER measures the incoming signal bits prior to decoding. On the other hand, F.E.R. measures the error rate after the incoming signal has been decoded. Factors such as the channel coding schemes or the frequency hopping techniques determine the correlation between BER and F.E.R. F.E.R. is used as the quality performance indicator for speech as the speech quality difference with the F.E.R. is uniform. A drive test provides the statistics to analyse F.E.R. Drive testing is capable of generating both the downlink and the uplink F.E.R.

Dropped Call Rate (D.C.R.): The dropped call rate (D.C.R.) measures the number of calls dropped in a specific network. A Dropped Call is one that gets terminated on its own after the call is established. The D.C.R. is one of the most vital parameters in network optimisation as it gives a clear overview of the network quality and the revenues lost. D.C.R. can be easily assessed by performing a Drive Test.

The following figure lists some features of DCR:

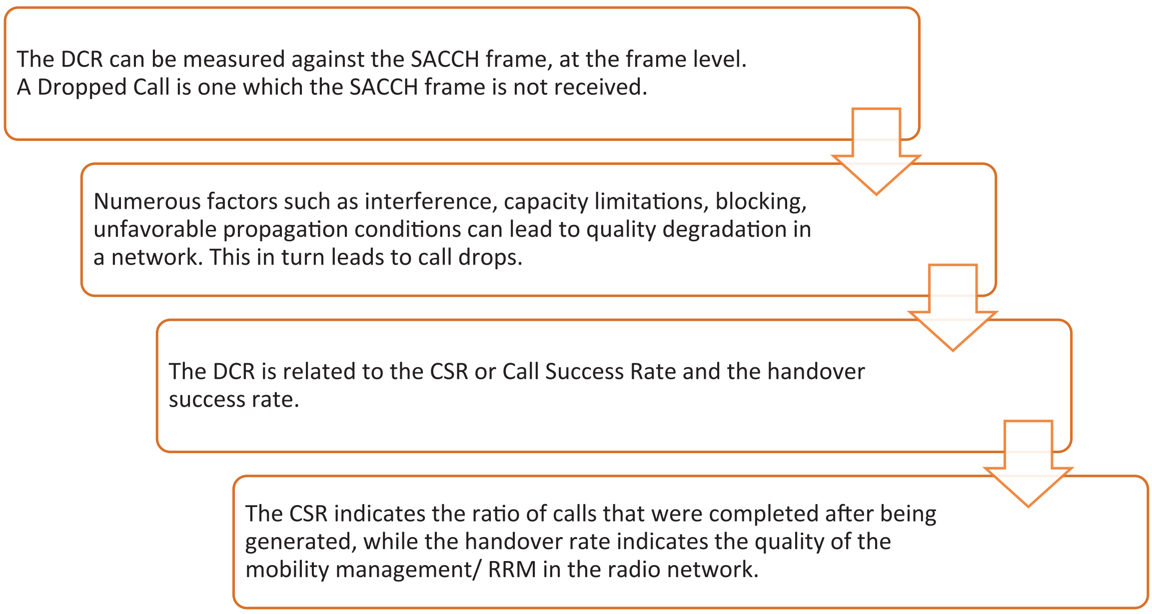


Fig. 1.4.3: Features of DCR

Designing KPIs

KPIs are more helpful when they are relevant, simple, and precise. They can provide useful guidance and insights for analysis. The following points need to be considered when selecting the KPIs that will offer the most significant business insight.

Characteristics	Definition
Pertinent	KPI is tied to call center vision and mission statements
Focus	KPI is reviewed, understood and acted upon by all employees
Accurate	KPI is viewed as accurate and statistically valid by all employees
Frequency	KPI is measured frequently (daily or weekly) and consistently
Accountability	KPI results are tied to all employees
Impact	KPI has a big impact on costs and customer service
Incentives	KPI results are tied to bonus/recognition programs for all employees

Fig. 1.4.4: KPI definitions

Delay analysis

One of the biggest challenges in network optimisation is to identify the location and the distribution of the users. The U.E. generally sends its data around 3 time slots later than when it receives the data from the B.T.S. However, if the user is far away, the signal will experience a delay as it goes through the radio path. The delay needs to be analysed so that appropriate time adjustment.

Practical

This activity is in the form of a Site Visit.

Pre requisite for Practical

- The trainer will take the participants to a telecom tower.
- The trainees should carry a Student ID, Notebook, Pen and Participant Handbook.

Demonstration

- The trainer will demonstrate the telecom tower infrastructure (passive and active) to the trainees and the participants.
- The trainer will show the passive and active components to the participants and will explain how the components work (significance of each component).

Post Demonstration

- The participants should take notes, and if they have any doubts, they should ask questions to the trainer.
- The trainer will clarify the doubts of the participants.
- At the end of the session, the trainer will thank the tower management authority for letting them in and allowing them to visit the technical hub.

Practical

This activity is in the form of a Lottery Question.

Pre requisite for Practical

- The trainer will keep a box in front of him/ her.
- The box will contain small pieces of paper folded in such a way that anything written inside is invisible.
- Each folded paper should have a term related to telecom architecture, such as eNB, Data Packet, HLR, MS, BTS, and BCCH

Demonstration

- The trainer will ask one participant at a time, and the participant will choose one folded piece of paper.
- The participant will say what he/ she knows about the term written inside the folded paper he/she has chosen.
- There should be at least three rounds of this game, and in case a participant gets a repetitive topic, he/ she will choose another paper.

Post Demonstration

- The class will appreciate the best performers
- The trainer will encourage cross-questioning and Q & A sessions among the trainees

UNIT 1.5: Spectrum Allocation and Its Functions

Unit Objectives

By the end of this unit, the participants will be able to:

1. Analyse the usage of spectrum in the telecom sector
2. Evaluate the spectrum management policy in India

1.5.1 Spectrum Management

To ensure efficient usage of radio frequencies, we use Spectrum Management. The term Radio Spectrum means the frequency range used for wireless communication, which is 3 kHz to 300 GH. However, the meaning of spectrum management is undergoing a drastic variation as the usage and demand of mobile devices and 4G services have increased tremendously.

Auction of Spectrums

Typically, the administration uses a special auction of spectrum to ensure proper allocation of spectrum, which involves:

A seller who targets to allocate an object to one of the buyers	A specific price mechanism used to distribute spectrum

Fig. 1.4.1: Features of spectrum auction

There are three main types of auction formats, as shown in the following figure:

First-price sealed bid auction	• The highest bidder wins the auction and pays an amount equal to the total bid amount. • The bid calculated by estimating what other bidders will be bidding.
Second-price sealed bids auction	• This method of auction is like the first-price sealed bid auction. • The highest bidder wins the auction but the bidder has to pay the price equal to the amount of the second highest bid.
Dutch auction	• The highest price of the auction is quoted and then decreased gradually. • The first one to bid for it wins the auction.

Fig. 1.4.2: Types of auction formats

The trend for the auction of spectrums has varied since its initiation. The trend is shown in the following figure:

The spectrum was included within the telecom license and the Department of Telecommunication (DOT) was responsible for auctioning.

→ In 1994, the National Telecom Policy acknowledged that the participation of non-Government entities was required alongside Government to achieve targets.

↓ Consequently, in 1995, bids were invited for private investment in the basic telecom services sector, through a competitive process.

→ India was divided into 20 circles, under categories A, B and C based on the potential of the region to generate revenue. Licenses were awarded to two operators per service area for cellular and basic telephone services.

↓ To be eligible for bidding for licenses, the service providers had to collaborate with a foreign company, so that the Indian company would have the financial capability and technical infrastructure to provide cellular/basic telecom services at a larger scale.

→ Next, the telecom service provider, which had fulfilled the pre-requisites and was the highest bidder for the license,

Fig. 1.4.3: Trend for auction of spectrums

In 1995, 2*4.4. MHz of start-up spectrum was auctioned for GSM-based services. The following table shows the allocation of spectrum based on the “Subscriber Based Criterion”, 2002:

Quantum of Spectrum Allotted	Minimum Subscriber Base Required (in millions)	Annual Spectrum Charges (per cent of the adjusted gross revenue)
2*4.4 MHz	-	2
2*6.2 MHz	-	3
2*8.0 MHz	0.5	3
2*10 MHz	1.0	4
2*12.5 MHz	1.2	5

Table 1.4.1: Allocation of Spectrum

[Source: Vardharajan Sridhar, The Telecom Revolution in India: Technology, Policy and Regulation, Oxford University Press, 2012, pp. 112]

Telecom Regulatory Authority of India (TRAI) Review

To identify the unused spectrum and its efficient and optimum utilization, TRAI reviewed the process of spectrum allocation in 2005. It was found that the maximum spectrum allocated to an operator is 2*10 MHz, whereas the international average is around 2*20 MHz. The main issue faced by spectrum allocation was spectrum usage by defence forces and the railways.

The Ministry of Defence and Railways used a large portion of the 900 MHz frequency band. The Indian Air Force uses the 1900 MHz, frequency band.

In the 800 MHz band, the CDMA operators were allocated a maximum of 2*5 MHz as against the global average standards of 2*15 MHz for CDMA operations. The chief reasons for the delay in the allocation of the spectrum are:

- Deviation from laid down procedures
- Inappropriate application of laid down procedures
- Violation of underlying principles of laid down procedures

Fig. 1.4.4: Reasons for the delay in the allocation of spectrum

The main transmission technologies are:

- Time Division Multiplexing (TDM)
- Dense Wavelength Division Multiplexing (DWDM)
- Frequency Division Duplex (FDD)
- Time Division Duplex (TDD)
- Time-Division Multiple Access (TDMA)
- Frequency Division Multiple Access (FDMA)
- Orthogonal Frequency Division Multiple Access
- Single Carrier- Frequency Division Multiple Access (SC-FDMA)

Time Division Multiplexing (TDM)

Transmitting and receiving individual signals over a common individual path using synchronized switches connected at either end of the transmission link.

Some characteristics of TDM are:

- Used mainly for digital signals but may be implemented in analogue multiplexing.
- Two or more signals, or bit streams, are transferred concurrently as sub-channels in a single communication channel.
- One TDM frame consists of a one-time slot per sub-channel, a synchronization channel, and sometimes an error correction channel before the synchronization.

Dense Wavelength Division Multiplexing (DWDM)

Multiplexing optical signals within a band of 1550 nm. A DWDN system uses a multiplexer at the transmitter's end to connect many signals and uses a demultiplexer at the receiver's end to separate the signals. DWDM has gained popularity within telecommunications companies because the companies can expand their network without laying out more cables/fibres.

The following figure shows a multiplexer and demultiplexer in a DWDM system:

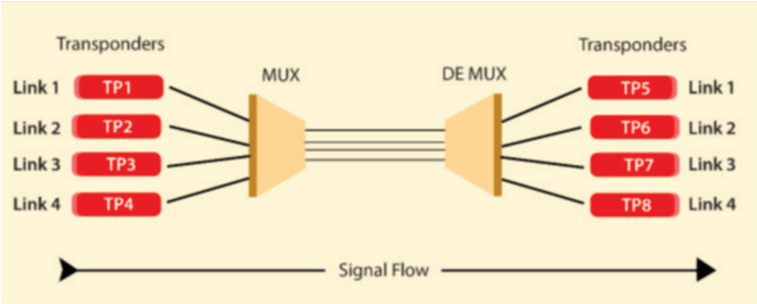


Fig. 1.4.6: Multiplexer and demultiplexer in a DWDM system

Frequency Division Duplex (FDD)

Uses a technology where the uplink and downlink use a separate frequency, where the gap in the frequency is known as duplex distance or spacing. It is used widely for wireless communications and simultaneous transmission and reception.

Time Division Duplex (TDD)

Uses duplex communication links. In this technology, the uplink gets separated from the downlink using various time slots within the same frequency band. Some characteristics of TDD are:

Fig. 1.4.7: Characteristics of TDD

Time-division multiple access (TDMA)

It divides the signal into separate time slots, thus allowing users to share the same frequency. This technology is used in 2G cellular communication, such as Global System for Mobile (GSM) communications. The following figure shows TDMA:

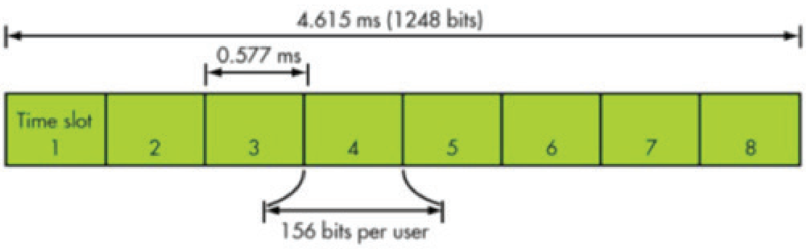


Fig. 1.4.8: Time-division multiple access

Frequency Division Multiple Access (FDMA): Divides the total spectrum (one channel or bandwidth) into numerous channels (or multiple bands), allowing each channel to be assigned to a separate user. The transmitted data is modulated on individual channels/bands, and all the channels are linearly combined. This technology is popularly used for analogue mobile radios and cellular mobile telephones such as AMPS, NMT and TACS. The following figure shows frequency-division multiple access:

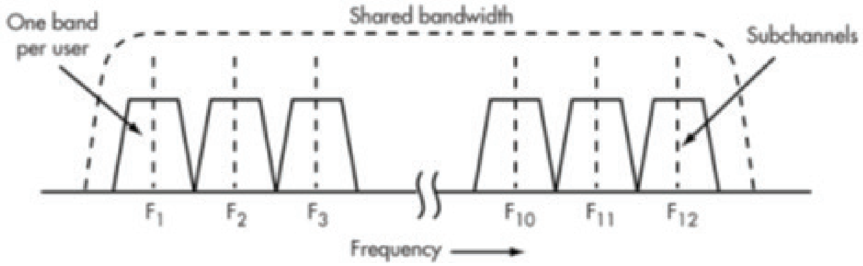


Fig. 1.4.9: Frequency-division multiple access

Orthogonal Frequency Division Multiple Access (OFDMA)

OFDMA is used in Long-Term Evolution (LTE) mobile systems to accommodate multiple users in a specific bandwidth. OFDM is a modulation method that segregates a channel into several narrow orthogonal bands. These bands are spaced out in such a manner that they do not interfere with one another. Every band is further segregated into hundreds (sometimes thousands) of 15-kHz wide, lower-speed streams, which are modulated over subcarriers.

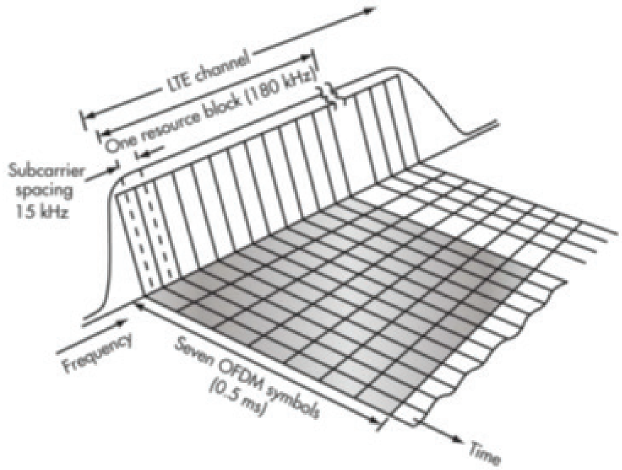


Fig. 1.4.10: Orthogonal Frequency-division multiple access

Time slots within each subcarrier data stream are used for packaging the data to be transmitted. The main advantage of using this technique is that it provides effective and efficient spectrum distribution and thus enables high data rates. Furthermore, the transmitted data is less affected by multipath propagation effects.

Single Carrier- Frequency Division Multiple Access (SC-FDMA)

SC-FDMA is a frequency division multiple access scheme that is similar to OFDMA. In SC-FDMA, each user is assigned contiguous subcarriers. This reduces the processing power and battery requirements for mobile devices.

Practical

This activity is in the form of a Site Visit.

Pre requisite for Practical

- The trainer will take the participants to a telecom tower.
- The trainees should carry a Student ID, Notebook, Pen and Participant Handbook.

Demonstration

- The trainer will demonstrate the telecom tower infrastructure (passive and active) to the trainees and the participants.
- The trainer will show the passive and active components to the participants and will explain how the components work (significance of each component).

Post Demonstration

- The participants should take notes, and if they have any doubt, they should ask questions to the trainer.
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- The trainer will ask one participant at a time, and the participant will choose one folded piece of paper.
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Post Demonstration

- The best performers will be appreciated by the class
- The trainer will encourage cross questioning and Q & A session among the trainees

Summary

- India holds a leading position in the current global telecommunications market
- The rapid growth of the Telecom Industry and the considerable increase in the number of subscribers have given ample reasons for the Telecom Tower Industry to flourish and establish itself as one of the aces of the economic market in India.
- There are many players in the Indian market when it comes to tower setup.
- An active network requires power; hence, they need a power source. Passive Infrastructures are the infrastructures that are not part of a Telecommunications Network's active layer
- Global System for Mobile Communication is a digital cellular technology used for transmitting mobile voice and data services.
- LTE is a fourth-generation (4G) wireless standard that provides increased network capacity and speed for cell phones and other cellular devices compared with third-generation (3G) technology.
- KPI analysis helps the drive test engineers to gauge the issues and find suitable solutions.
- To identify the unused spectrum and its efficient and optimum utilization, TRAI reviewed the process of spectrum allocation in 2005.
- The Ministry of Defence and Railways used a large portion of the 900 MHz frequency band. The Indian Air Force uses the 1900 MHz, frequency band.
- Transmitting and receiving individual signals over a common individual path using synchronized switches connected at either end of the transmission link.

Exercise

MCQ

1. Which of the following is a component of passive infrastructure?

   a) Shelters   b) Poles

   c) Towers   d) All of the above

2. Switches, wireless routers, and transceivers are ____________________ equipment.

   a) Active   b) Passive

   c) Both (a)and (b)   d) None of the above

3. GSM stands for_____________________

   a) General System for Mobile Computing

   b) Global Structure for Moveable Communication

   c) Global System for Mobile Communication

   d) None of the above

4. ________________ is used for the storage and manage permanent data about subscribers, such as subscriber's service profile, location information, and activity status.

   a) Home Location Register (HLR.)

   b) Mobile Switching Centre (MSC.)

   c) Network Switching Subsystem (NSS.)

   d) None of the above

5. _____________________ divides the signal into separate time slots, thus allowing users to share the same frequency.

   a) Frequency Division Duplex (FDD)

   b) Frequency Division Duplex (FDD)

   c) Time Division Multiple Access (TDMA)

   d) None of the above

Descriptive Question

1. What is Time Division Multiplexing (TDM)?
2. Differentiate between Bit Error Rate (BER) and Frame Error rate (FER).
3. What is the function of the Visitor Location Register (VLR)?
4. Differentiate between active and passive infrastructure.
5. What is Scrambling Code Optimisation?

Notes

Scan the QR codes or click on the link to watch the related videos

https://youtu.be/Cag-bcbivtM

Introduction to Telecom Industry in India

https://www.youtube.com/watch?v=RelEnn3L92I

Major tower companies in India

https://www.youtube.com/watch?v=ymmPnV2NVCM

Different Mobile Networks and their Technologies

https://www.youtube.com/watch?v=ot42qPfgG_U

UMTS (Universal Mobile Telecommunications Service)

https://www.youtube.com/watch?v=vl51IV_1SQw

LTE (Long-Term Evolution)

Skill India
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Transforming the skill landscape

2. Tower Site Verification and Preparation for Drive Test

Telecom
Sector
Skill
Council

Unit 2.1 - Types of Telecom Towers

Unit 2.2 - Verification of Tower Parameters

Unit 2.3 - Passive Network Components/Equipment

Unit 2.4 - Drive Test Equipment and Tools

TEL/N6237

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Identify various types of towers on site
2. Inspect the tower site
3. Identify the latitude and longitude of the site (Tower ID)
4. Evaluate the height, tilt and orientation of the antenna as per the given parameter
5. Analyse sector swap as per defined parameters
6. Demonstrate how to EMF survey as per company norms
7. Analyse the Active and Passive Infrastructure on Tower Site
8. Identify the types of antennas and their radiation patterns
9. List the functions of drive test equipment

UNIT 2.1: Types of Telecom Towers

Unit Objectives

By the end of this unit, the participants will be able to:

1. Distinguish different types of telecom towers (GBT, RTT, Pole)
2. Explain the functions of different towers

2.1.1 Telecom Tower

With the upsurge in mobile subscribers, there is a constant need to provide efficient network connections to every mobile user in India. Telecom towers ensure effective wireless communication and ensure a strong network with optimised bandwidth. In order to reduce call dropout, telecom towers are installed in various geographic locations. Various types of telecom towers are installed to carry out this connectivity network.

Based on the position or the place of installation, the telecom towers are broadly categorized as:

Ground Based Tower (GBT)

The ground-based towers are installed on the ground with a suitable foundation. The towers have 30-200m; a ground-based telecom tower height is 40m. These towers can support up to 12-panel antennas and up to three 0.6m diameter microwave solid dish antennas. These towers have a competitively higher load-bearing capacity.

The average cost of installing a GBT is approximately ₹ 2.5 million. A GBT can accommodate 42 callers if the TRX configuration at the site is 2 + 2 + 2 (in full rate). In the case of half rate, the number reaches 84.

Fig. 2.1.1: Ground-Based Tower

Rooftop Towers (RTT)

The rooftop towers are installed above the roof of a high-rise building. The towers are installed on the roof with raised columns and tie beams,. The height of the tower can vary from 9m to 30m. The service provider evaluates the tower erection and the height to decide on the number of antennas that can be attached with the tower.

In metropolitan cities like Kolkata, Mumbai, Chennai, and Delhi, the number of high-rise buildings is enormous and thus, the tower industry prefers to install towers on rooftops.

RTT can accommodate 42 callers if the transceiver (TRX) configuration at the site is 2 + 2 + 2 (at full rate). In the case of half-rate, the number reaches to 84.

Fig. 2.1.5: Roof top tower

TRX is a transceiver device widely used in Telecom to receive and transmit signals. Typically, a TRX comprises both the transmitter and receiver.

Verifying the site and site parameters

The installation of RTT requires a meticulous survey of the site. The height of the tower depends on the height/strength of the building on which the RTT is installed. For example, A tower of 80 meters cannot be installed on a building that cannot provide sufficient support or strength to cope with it. Moreover, the tower company should procure approvals of the tenants and proper regulatory documents before the installation of the RTT.

The following table shows a comparison between GBT and RTT:

Type of Tower	Site of Installation	Average Height	Average Tenant Accommodation
GBT (Ground Base Tower)	Available land at the ground level in the rural or suburban areas	40-80 meters	42 (Full Rate) 84 (Half Rate)
RTT (Roof Top Tower)	On the roofs or terraces of high-rise buildings	Depends on the height and strength of the building on which the RTT is installed	42 (Full Rate) 84 (Half Rate)

Table 2.1.1: Comparison between GBT and RTT

Roof Top Pole (RTP)

Engineers have designed Pole Towers because of the rapid growth of the telecommunication industry, a huge increase in the number of subscribers, and the necessity of installing towers at remote locations. The advantages of Pole Towers are:

- Pole Towers occupy less space
- Since Pole Tower can be installed on a significantly stipulated space, the cost of the purchase of the land for installation is low

- Pole Towers are easy to install
- Pole Towers support both GSM and CDMA
- The design of Pole Towers is considerably simple and involves few components
- The installation of antennas on Pole Towers is easy and effective

Fig. 2.1.6: Rooftop tower Roof top pole

Coverage on Wheel

C.O.W. is an acronym for “Coverage on Wheel” or “Cell on Wheel”. C.O.W. is a mobile cell site product that is mounted on a truck or trailer. It consists of a transceiver, a tower and other essential equipment. These portable towers are used temporarily (short-term), as they are not installed for permanent services.

Generally, C.O.W. towers are used for creating or boosting a cellular network for a brief period, such as an emergency, a big event, or while a full tower is being built. However, if required, a high-quality C.O.W can be employed for a longer period of time.

Fig. 2.1.7: Coverage on Wheel or C.O.W

Advantages of Coverage on Wheel

- A C.O.W. tower is used when strong cell signals are required for a short time (temporary basis)
- In cases of emergency, such as after a major flood or storm, Coverage on Wheel becomes a handy option

- During prominent events (Olympics or World Cup games) that require huge media coverage, Coverage on Wheel serves the purpose for a given area on a temporary basis
- In cases of outages (for example, during a renovation of the main cell site), Coverage on Wheel acts as a substitution for the main tower.

Lattice towers

Prior to the introduction of Pole Towers, Lattice Towers were widely installed. Even today, one can find many lattice towers, especially in rural areas and hill stations.

Lattice towers are also referred to as "self-supporting towers". These freestanding towers are segmentally designed with triangular and rectangular base steel, and the diagonal zigzag or spiral design is the hallmark of the lattice towers. The lattice towers have a flexible design which means they are useful in a situation where modification is required, such as connecting a dish antenna and several panels. These are mostly used for heavy-load electricity transmissions, such as radio and observation towers.

Fig. 2.1.8: Lattice tower

Tubular Tower

The tubular steel towers are installed for maneuvering high loads. These towers are manufactured with elements in tubular sections that are joined together to enhance the strength of the tower. These towers are mainly installed in deserted areas, like on the outskirt of the city, to improve the network spectrum.

Fig. 2.1.9: Tubular Tower

UNIT 2.2: Verification of Tower Parameters

Unit Objectives

By the end of this unit, the participants will be able to:

1. Identify the different types of antennas
2. Analyse the radiation pattern of the antennas
3. Explain the principle of directional antennas, sectorization, tilting (E/M), frequency bands, GSM architecture
4. Identify the latitude and longitude of the site (Tower ID)
5. Evaluate the height, tilt and orientation of the antenna as per the given parameter
6. Analyse sector swap as per defined parameters
7. List EMF survey as per company norms

2.2.1 Types of Antennas

Types of antenna used in cell towers based on functionality:

Omnidirectional Antenna: These are used to transmit/receive in any direction. Example: dipole antennas

Directional Antenna: These are used to transmit/receive in a particular desired direction only. Some of the examples include horn antennas of circular and rectangular types.

Antennas are arranged in an array to develop a directional antenna. The two types of array are parasitic arrays and driven arrays. The types of configurations in which they are arranged are explained above.

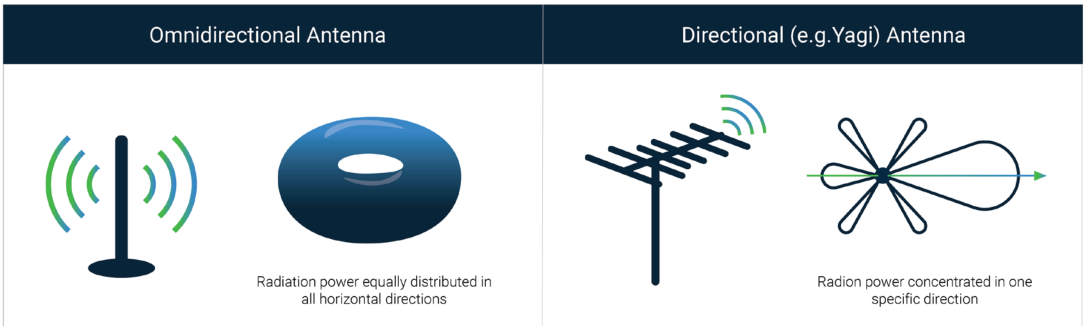

Fig 2.2.1 Types of Antennas used in Cell Towers

Types of Antennas based on R.F. Energy

There are two primary types of antenna used in cell towers, and each type has different functions and purposes when it comes to transmitting and receiving R.F. energy. Take note that most cell towers have both of these types of antennae placed at the top, but there may be some that only has one.

Rectangular antenna

A rectangular antenna, called a panel antenna or radio antenna, is used to transmit and receive waves or data between mobile phones or other devices and the B.T.S. (base transceiver station). Out of the two types, the rectangular antenna has the longest reach, as it is intended to connect mobile phones that may be far away from its vicinity. The rectangular antennas are the ones that handle 2G, 3G, and 4G services for cell providers.

Circular Antenna

This is also called a parabolic dish antenna. The circular antenna is utilised to transmit waves or data from one B.T.S. to another, which strengthens the signals from these cell towers. You can look at these circular antennas like the nerves of the cell towers' network, and then the rectangular antennas serve as the organs that need transmissions from the nerves in order to function.

Circular antennas have shorter coverage than rectangular ones, mainly due to the fact that they are just used for the communication of cell towers that are commonly closer to each other in one specific area. Plus, they also have a narrower coverage compared to panel antennas because of their circular shape, but it allows them to maximise their signal reception from another cell tower since its transmission and receiving capabilities are much more focused. In addition, the signal that a circular antenna transmits is directional, and they perform point-to-point links to towers instead of receiving waves or data from multiple phones and devices.

Cell Towers

Cell towers are important structures for our cell phones and other devices to connect to the network. Most major cell providers would often build their own cell towers at specific places in the country to expand their coverage and give their customers a fast and responsive experience using mobile data. In some cases, cell providers would often share one cell tower if there is no more space in the area to build another one.

Fig: 2.2.2 Cell Tower

Plenty of components are involved in building a fully-functioning cell tower, but one of the most important of all is its antenna, which is supposed to receive and transmit data in the network.

For calls or texts, a mobile phone must first send electromagnetic waves that are also called R.F. (radio frequency) energy. After the cellular phone sends the R.F. energy, the antenna will then be able to receive it and automatically transmit the waves to a switching centre or a base station. Next, the station or the centre will connect it to the cell tower near the area of the phone you are calling or texting.

For a Wi-Fi tower, it will automatically transmit data or waves to your router as long as it is turned on. Like the towers, your wireless router also has built-in antennas, and the total number of antennas depends on its quality and its price. The cheapest routers usually have two dipole antennas. In comparison, the most expensive ones have eight antennas, which are much more suitable for online gaming. You would need to have large amounts of data and bandwidth to play without any lags or disconnections.

2.2.2 Principle of Directional Antennas

Cell Sectors

At least three rectangular antennae are placed on a cell tower, and each antenna will be able to cover an area within 120 degrees. So, if the cell tower has three facing in different directions, it will be able to get 360 degrees of coverage.

Also, these antennae are typically located at the top of the tower so that it will have a wider and longer range compared to the other type. One rectangular antenna propagates a signal at a semi-directional movement, while three combined panel antennas can propagate in an omnidirectional manner. If we observe a telecom tower, we will notice that the positioning of the antennas is unique.

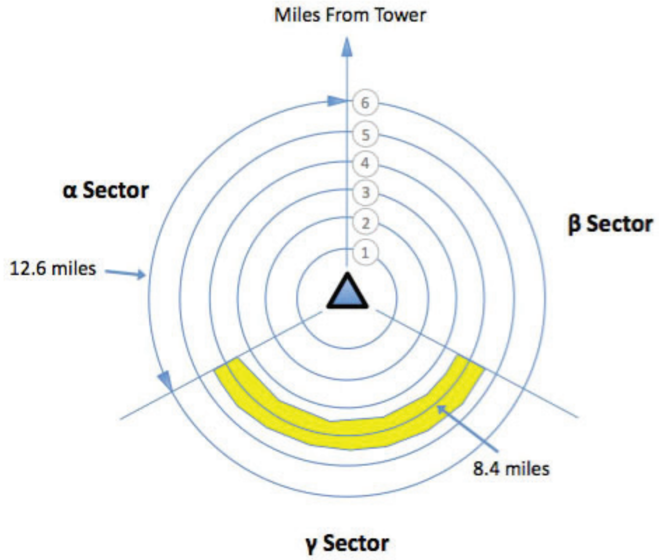

Fig. 2.2.3 α (alpha), β (beta) and ϒ (gamma) sector

The towers are placed so that they cover a wide area with a high population. Each antenna attached to the tower covers a significant zone or area, and this zone is known as the sector. Each antenna array covers a 120o sector, by convention, known as α (alpha), β (beta) and ϒ (gamma) sectors. The following figure shows the α (alpha), β (beta) and ϒ (gamma) sectors.

Let us consider an example.

A signal is received from the ϒ sector. The cell tower first interprets the sector from which the signal is coming and then measures its distance from the tower. After locating the sector and the distance, the tower interprets other data like signal strength, frequency, and impediments.

Let us assume that a signal is coming to a cell tower from ϒ sector, and the distance between the source of the signal and the tower is 4 miles. The next thing the tower does is place the signal within a towering band. A tower band is a fringe or a strap. Each tower band has unique tower strengths. A fringe or band nearer to the tower has more tower strength than a band at a distance of 4 miles.

The following figure shows a signal from the ϒ sector:

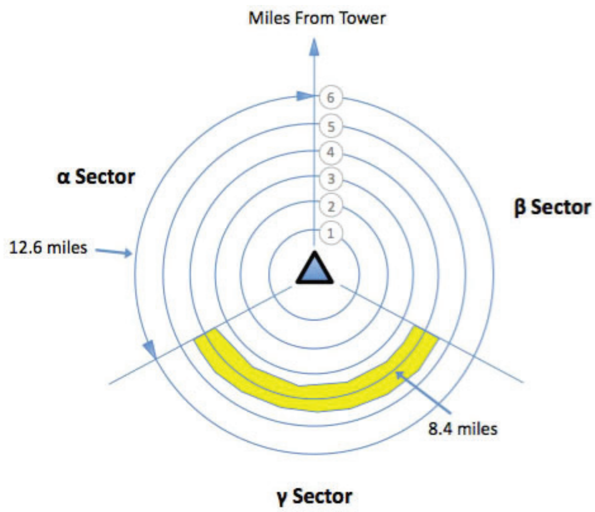

Fig. 2.2.4: Signal from ϒ sector

Let us say a caller is trying to make a call from the yellow-band zone. The blue tower will first interpret the I.D. of the tower band, i.e., the sector and distance of the signal. Once the tower receives the signal, it takes further steps like processing the signal or routing it.

Let us take an example of a zone that falls in an overlapping region of two sectors. There might be two cell towers in the vicinity. In that case, the area covered by the cell towers is the overlapping or the intersecting region. If a call has been made from such a region, it falls under two different tower bands

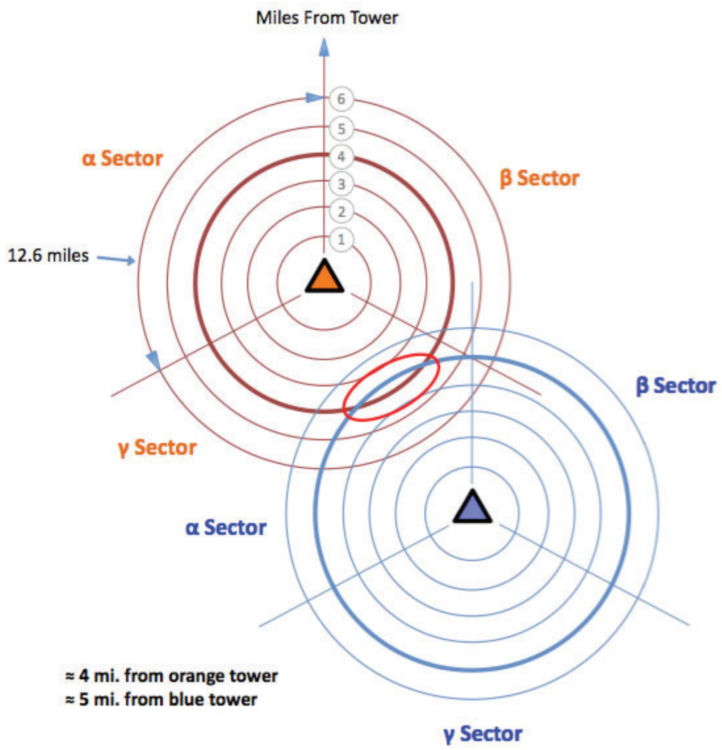

Fig: 2.2.5: Overlapping region

For example, a caller makes a call from a distance of 4 miles from the orange tower (picture given below) and 5 miles from the blue tower. In the case of the orange tower, the caller falls within the ϒ sector, and in the blue tower, the caller falls within the α sector. Now, the signal or in a broader sense, the caller, has two separate towers I.D.s. The following table shows the distance of a caller from two towers:

	Sector	Distance
Orange Tower	ϒ	4
Blue Tower	α	5

Table 2.2.1: Distance of a caller from two towers

In this case, the scope of finding out the exact location of the caller becomes easier. If the caller remains in an isolated, vast tower band, pointing out the exact location becomes difficult. However, if the caller falls within a common region or overlapping region, the location of the caller can at least be narrowed down to a particular region. In the case of an urban area, where the towers are installed close to each other, the chances of overlapping sectors with more than 2 towers are high. The caller's exact location can further be narrowed down to even a smaller range of the band due to multiple tower overlaps.

So, a Tower ID consists of mainly two parameters:

- The Sector from which the signal is originating
- Distance between the tower and the point of origination of the signal (source of the signal)
- The specific range or tower band within which the source of the signal lines

The below figure shows an example of multiple towers overlapping.

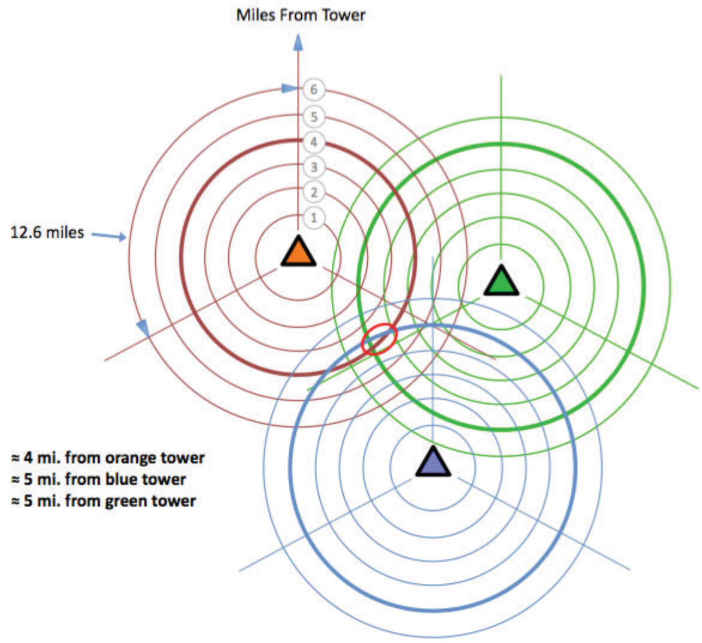

Fig 2.2.6: Multiple towers overlapping

Modern handsets provide the facility of G.P.S. tracking, which gives more accurate information about the caller's location; thus, TowerID tracking is gradually becoming obsolete.

The sectors normally cover the following areas around a tower:

- α: approximately North to North-East
- β: approximately South to South-East (120° clockwise from the first sector)
- ϒ: approximately West (1200 clockwise from the second sector)

Latitude and Longitude of the Site

Scientists have drawn sets of imaginary lines on the map to locate a specific place. There are sets of imaginary circular lines drawn from East to West, measured from the Centre of the earth, known as latitude. The Centre of the earth is the biggest circle drawn on the globe. This circle (or latitude) is the equator. The latitudes are drawn on the map from the equator to the poles. The latitude in the polar region is merely a dot.

Latitudes are measured in degrees (°).

- The latitudinal magnitude of the equator is 0°
- The latitudinal magnitude of the polar regions is 90°

The direction of the latitude is expressed by putting the first letter of the half (North and South) on which a particular place falls. For example, if a place is located in the Northern half and the latitude of the place is 500, then the exact location of the place is expressed as 500N. If the place were in the Southern half, it would have been expressed as 500S.

The following figure shows the latitudes measured from the Equator:

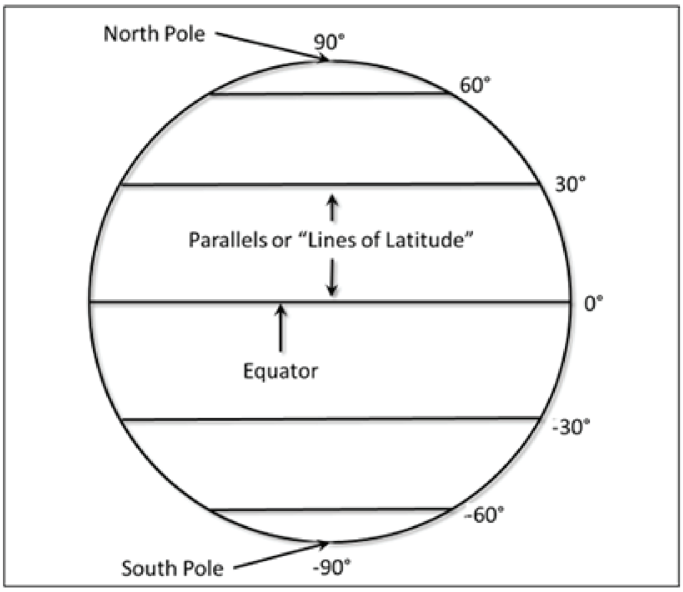

Fig 2.2.7: Latitudes (measured from the Equator)

Latitudes are the set of imaginary lines drawn from East to West. Like the Equator, the Latitudes have a pivotal point as the point of reference. The line running from North to South through Greenwich, England, is known as the Prime Meridian. Longitudes are also imaginary circles drawn from North to South with the Prime Meridian at the centre.

This refers to the fact that one-half of the world is measured in degrees of east longitude up to 180°, and the other half in degrees of west longitude up to 180°.

The position of the place determines the direction of the longitudes. For example, if a place is located East at a longitudinal magnitude of 450, the location is expressed as 450E. If the place is the Western half, the location would be 450W. The following figure shows the longitudes running from North to South.

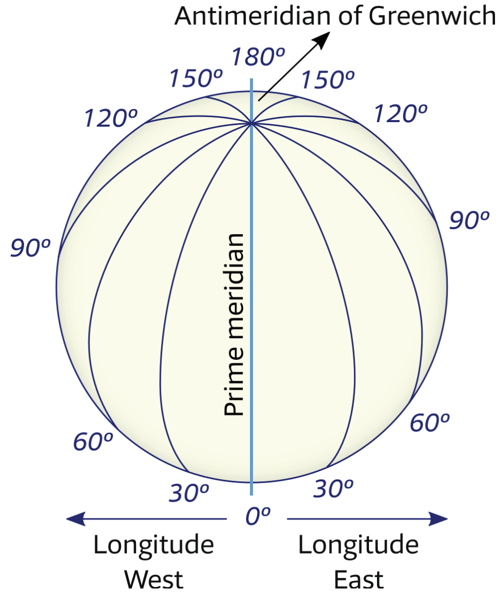

Fig 2.2.8 Longitudes run from North to South.

Latitude and Longitude of Telecom Towers

Every telecom tower has a unique latitude and longitude. The measurement of the latitude and longitude is also an integral part of the tower I.D.

For example, a Tower is installed at a location which has the following magnitudes:

- Latitude of 75° in North
- Longitude of 125° in East

Therefore, the location of the place in terms of latitude and longitude will be expressed as:

75°N, 125°

As we have already discussed the sectors and the distance theory, the knowledge of latitude and longitude adds more accuracy in locating the source of the signal. A caller can be tracked, or the location can be narrowed down to the sector, latitude, longitude and sector (Tower Band). However, the latitude and longitude of a place are accurately deciphered by the G.P.S. tracking.

Effect of antenna tilt, direction, azimuth and height on performance

Antenna Height

There is a general law of antenna height formulated based on the wavelength of the telecommunication signal. According to the law, the height of the antenna should be a quarter the magnitude of the wavelength.

For example, If the magnitude of a telecommunication signal is 40 Hz, the height of the antenna receiving the signal should at least be ¼ of the magnitude, which is 40.

Therefore, the height of the antenna should be ¼ of 40, which equals 10. Thus, the height of the antenna should be at least 10 meters.

The Antenna Height Formula:

The height of the antenna = ¼ of the magnitude of the wavelength of the receiving signal.

In more generic terms, if the magnitude of the wavelength is ϒ, the height of the antenna should at least be ϒ/4.

The antenna's required height decreases with the signal's frequency rising, and thus, modulation is done. With modulation, a low-frequency signal gets shifted to a high-frequency signal. Another critical aspect of the antenna height is the location.

If the tower is situated in an urban area, it should acquire a much higher magnitude.

To receive the signals accurately, the height of the antenna should be more than the impediments. In urban areas, the possibility of impediments is high with skyscrapers.

- Antennas receive the signals smoothly if there is less impediment between the source of the signal and the antenna
- High-rise buildings are potential impediments to the antennas
- To avoid receiving weak signals, the antenna height should exceed the height of the high-rise buildings around it.

Antenna Tilt

Antenna tilt is the angular position of the antenna, which determines the approximate downward angle of the antenna. The downward inclination is measured in degrees (0). Antenna tilt is required to receive optimum signal strength and coverage.

In technical terms, azimuth is the horizontal angle measured clockwise from a fixed plane of reference, such as a base direction line. The calculations are shown below:

The antenna tilt can be broadly categorised into two types:

Mechanical Tilt	Electerical Tilt

Fig. 2.2.8: Types of antenna tilt

Mechanical Tilt

The mechanical tilt tilts the antenna through specific accessories on its bracket without changing the input signal phase. This modifies the signal propagation direction.

The following figure shows the mechanical tilt of an antenna.

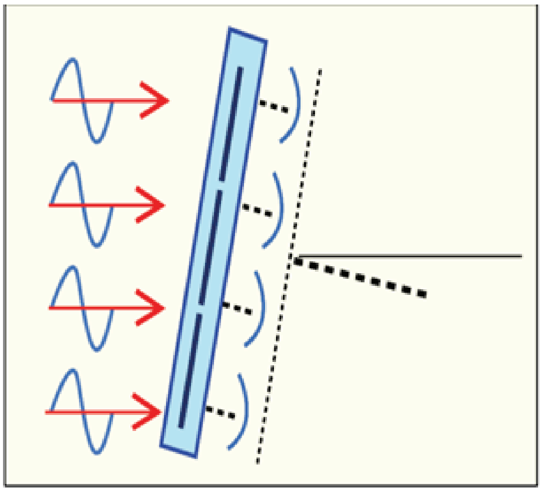

Fig 2.2.9 Mechanical tilt

Electrical Tilt: The electrical tilt is obtained by changing the characteristics of the signal phase of each element of the antenna. The following figure shows the electrical tilt of an antenna.

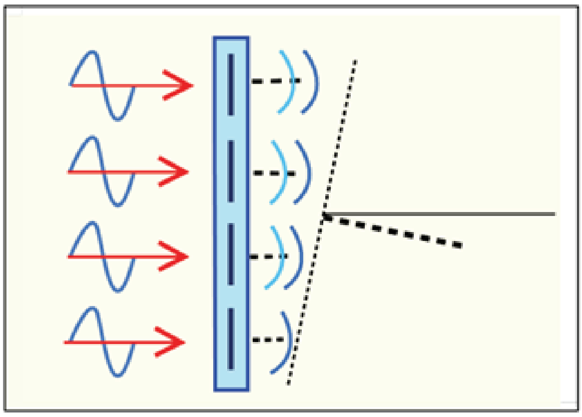

Fig 2.2.10 Electrical tilt

The antenna tilt is calculated on the basis of several parameters:

- The height of the transmitter
- The height of the receiver
- The distance between the source of the signal and the antenna
- The radii of the beam (commonly known as beamwidth)

The equation is:

$$A_{dt} = \tan^{-1}\left(\frac{H_t - H_r}{Distance}\right) \quad Rad_{inner,outer} = \frac{H_t - H_r}{\tan(A_{dt} \pm A_{bw})}$$

- Ht = Height of the transmitter
- Hr = Height of the receiver
- Adt = Distance between the source of the signal and the antenna
- Abw = Beamwidth

The following figure shows the calculation for the antenna downhill.

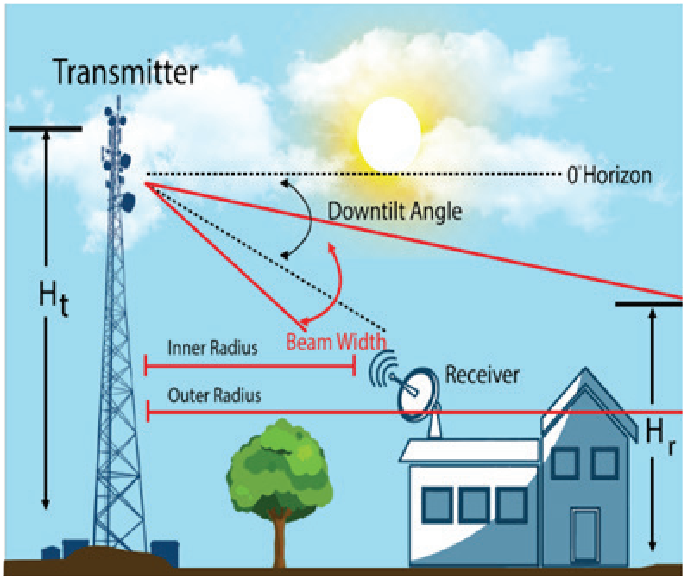

Fig. 2.2.11: Antenna downhill should be calculated to the optimum value for better coverage

Determining the optimum antenna tilt is absolutely necessary. If the antenna tilt is not set to the optimum numeric value, it might result in:

- Weak signal
- Poor coverage
- Shortening of the coverage area
- Broken signal

How to check antenna Azimuth?

- Stand in front of the Antenna
- When taking compass readings, keep at least 8m distance from any magnetic, metal, or current carrying structures such as towers, vehicles, or cables for correct readings
- Open the compass and wait a moment till the compass needle is stationary
- Check the antenna azimuth with reference to North & measure the value in degrees
- Compare the observed value with the one in the TSSR
- In case a mismatch is detected, make corrections on site
- Mention the values in the checklist for pre-post comparison and for database tracking

Antenna Orientation

Orientation refers not only to set the antenna in the correct direction but also to setting an accurate down tilt. By limiting the emitted energy to a circular arc and narrow vertical coverage, the design makes productive utilisation of apparently low-power transmitter equipment. This configuration allows reasonable data rates and a robust and consistent signal within the coverage area.

Antenna orientation is the summation of optimum set-up in terms of the antenna's height and down tilt. The main focuses of antenna orientation are:

- To procure a good coverage area
- To ensure maximum strength of the coming signals
- To broaden the coverage area with good signal strength

2.2.3 Ascertain Sector Swap as Per the Defined Parameters

A common fault in mobile communications networks is the presence of swapped sectors. This is, coverage areas of two or more co-located sectors are swapped. The reason for swapped sector's existence is the interchange of feeders' connections from baseband units or radio units to antennas' ports.

As we have already discussed that each tower has three sectors:

1. Alpha (α)
2. Beta (β)
3. Gamma (ϒ)

Each sector has a designated port to receive a signal from the tower band. So, we can say that Alpha, Beta, and Gamma have Alpha Port, Beta Port and Gamma port, respectively.

SWAP refers to the fact of interchanging the port and the wire of the sectors.

The following table shows sector swap:

	Port	Cable
Alpha (α)	α	α
Beta (β)	β	β
Gamma (ϒ)	ϒ	ϒ

Table 2.2.2: Swapped Sector

This is the standard set-up of the cables and the ports in the sector-antennas. Now, a swap is the exchange of the port and wires among the sectors. Therefore, if the α cable is inserted into the β port, it will conclude that a sector swap has taken place.

In the case of sector swap,

- If α cable is swapped with β port or β cable is swapped with α port, then you will get α P.N. in β direction and β P.N. in α direction
  - The P.N. junction diode is a two-terminal device. It is formed when one side of the P.N. junction diode is made with p-type and doped with the N-type material. The PN-junction is the root of semiconductor diodes.
- Sector swap is often referred to as cross-feeding
- Cross feeding results in weak signal strength and dropped net-speed

2.2.4 Perform E.M.F. Survey as per the Company Norms

E.M.F. survey stands for Electromagnetic Field survey. As it deals with signals, telecom towers are susceptible to generating radiation. The radiations are harmful to human health. Thus, a thorough survey needs to be conducted to avoid adverse effects of radiation.

In urban areas, the amount of radiation is quite high due to the congestion of telecom towers. A survey has disclosed the fact that not only human beings but also birds and other animals fall victim to it.

For example, the number of sparrows has steeply declined in the last decade, owing to the harmful effect of telecom radiation.

Therefore, the E.M.F. survey has become indispensable to avoid such calamitous aftermaths.

The scope of work in the case of the E.M.F. survey has two separate verticals depending on the following parameters (as per the regulations of the Indian Government):

- The scope of work in terms of Site Layout
- The scope of work in terms of Photography

The scope of work is based on the Site Layout

- Build a two-scale site layout diagram on paper and mark the location of the Antennae and Tower in the North Direction for all the operators. The layout should ideally be on CAD/PPT
- Mark every corner of the building (C1, C2, C3, C4) in terms of the distance from the antennae
- Define the building outline for the buildings falling within 20 m radius on the layout as per distance from the site and orientation
- Denote the publicly accessible points detected for each antenna where relevant
- A laser distance meter should be used for measuring building distances and heights
- Magnetic Compass to be used to measure the direction of the celestial objects (expressed in the angular distance in degrees)
- Provide a soft and hard copy of the site layout

The scope of work based on the Photography

- Photograph of rooftop depicting the site layout (Tower Location/Antennae/Water Tank)
- Photograph of Rooftop Pole/Rooftop Tower/Ground-based Towers depicting the antennas installed and points C1, C2, C3, and C4 (corners of the building)
- Panoramic photographs starting from 00 N with a spacing of 300
- Photograph of adjacent buildings within a 20-meter radius to be marked in the photograph as B1, B2, B3, B4 etc.
- A camera with an image resolution of 5 M.P. or above should be used to take a photograph
- Provide a soft and hard copy of the photograph

UNIT 2.3: Passive Network Components/Equipment

Unit Objectives

By the end of this unit, the participants will be able to:

1. Identify the passive network components/equipment
2. Explain the functionalities of AMT (Amplifier Mount Transceiver) and passive infrastructure equipment on site (e.g., DG, PIU, SMPS, Tower, Cables, shelter, etc.)
3. Discuss the advantages of the passive components

2.3.1 Passive Infrastructure on Tower Site

A passive component does not require any energy to operate, except for the available AC/DC circuit that it is connected to. A passive component is neither capable of power gain nor a source of energy. Any equipment except the antenna in a telecom tower sector is considered a passive component.

The following figure shows the components/parts that fall under the passive infrastructure of a telecom site:

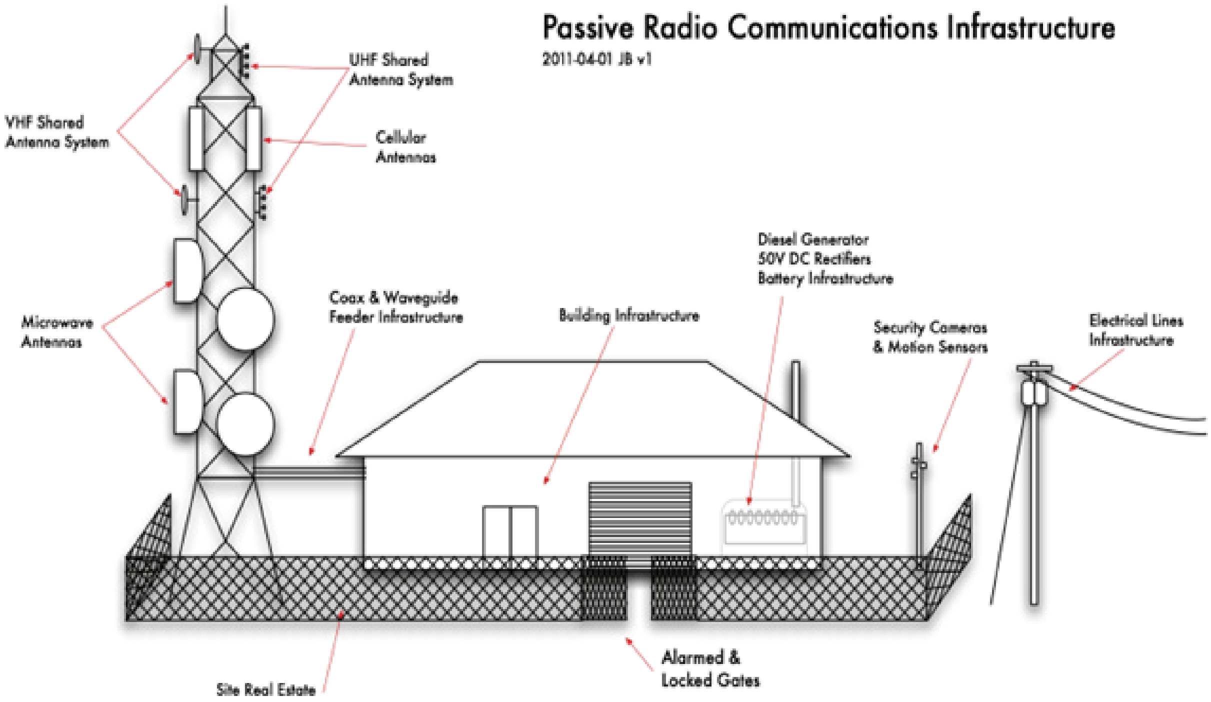

Fig. 2.3.1 Passive Infrastructure of the Telecom Sector

The Passive Components are:

- DG (Distributed Generator or Diesel Generator or Digital Generator)
- PIU (Power Interface Unit)
- SMPS (Switched Mode Power Supply)
- Tower
- Cables
- Battery bank

- Antenna
- Shelter

DG (Distributed Generator or Diesel Generator or Digital Generator)

Distributed generation systems are used to provide electricity during power outages, including those that occur after severe storms and during high energy demand days.

Fig. 2.3.2: Distributed Generator

Distributed Generator is a stationary generator that may be used during an emergency, during testing, and for maintenance purposes. Distributed Generation is the process of generating and storing electrical energy.

- Numerous power grids perform the generation and storage
- This helps the towers accumulate a certain amount of energy and use it at a time of scarcity.

PIU (POWER INTERFACE UNIT)

P.I.U. converts A.C. power supply (3 phase) to 230 volts of A.C. It helps to stabilise the process and nullifies the intervention of surge or external interferences.

In telecom, P.I.U. is used to provide A.C. power supply to the sheltered equipment and to control D.G. Power Interface Unit is an ideal solution for Telecom Sites in areas having wide fluctuations and surges in the mains supply.

Fig. 2.3.3: Power Interface Unit

SMPS (Switch Mode Power Supply)

SMPS is the power supply to the whole unit. It can fetch and supply both A.C. and D.C. current. SMPS can convert A.C. to D.C. and vice versa as per requirement.

SMPS is a handy and portable device, and thus it is widely used by operators.

Fig. 2.3.4: Power Interface

Tower

A Telecom tower is a trivial depiction of the radio masts and towers to hold telecom antennas. Towers provide the height required by the antennas to receive and transmit signals. Towers are built either on the ground or on the roof. Tower provides stability to the antennas so that the antennas do not suffer much due to heavy wind or floods.

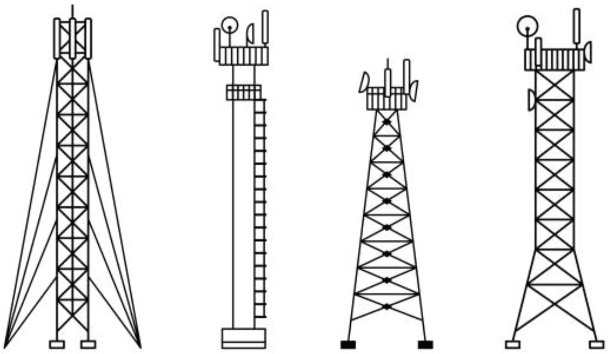

Fig. 2.3.5: Telecom Towers

Cable

- Telecommunication cables are the transmission medium.
- These cables carry electromagnetic waves (signal) from the source to the destination
- A feeder cable is used to denote the same or different wires bundled together as a single line of cable.
- A jumper cable is a pair of long, thick, insulated electrical wires with large, clamp-like terminals used to start a motor vehicle's engine by connecting its dead battery to a live battery

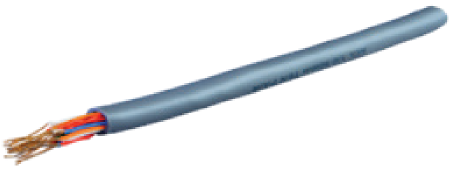

Fig. 2.3.6 Telecommunication in cables

Shelter

Shelter, in the telecom industry, refers to the buildings which safeguard the telecom equipment

- Shelters are built on the roadside, away from the main switching centre
- Shelters have backup systems attached to them to provide better service to the local server

Fig 2.3.7 Shelter

2.3.2 Advantages of Passive Infrastructure Sharing

- Sharing telecommunication infrastructure among telecom service providers has become an essential requirement and business process in the telecom industry.
- Competitors (telecom service providers) are becoming partners to decrease the costs of investments.
- The method and degree of infrastructure sharing can change in each country based on the competitive and regulatory climate.

UNIT 2.4: Drive Test Equipment and Tools

Unit Objectives

By the end of this unit, the participants will be able to:

1. Demonstrate the use of various equipment/tools to measure/perform during the site audit
2. Explain the functioning of the measuring equipment
3. Install/configure drive test measurement and recording software

2.4.1 Test and Measuring Equipment

The Drive Test Engineer must arrange the tools and equipment required for performing a site audit and drive test.

The following table lists the various test and measuring equipment:

Magnetic Compass • Two ends of a magnet, when suspended freely, always direct to the North and the South • The directions are confirmed by observing the position of the sun and the stars (which end directs towards the North and which end directs towards the South) • The magnetic compass is a portable and sophisticated device with a magnet inside it. The magnet ensures the direction by pointing to the North and the South	 *Fig. 2.4.1 Magnetic Compass*
Handheld GPS • GPS stands for Global Positioning System. • Hand GPS devices receive information from GPS satellites. • GPS devices are capable of deciphering the geographical position of the device. • GPS devices have a world map programmed, allowing the device to trace or find a destination. • In telecommunication, GPS is used mostly to trace the signal source (previously, it was detected by sectorization).	 *Fig. 2.4.2 Handheld GPS*
Tilt Meter • The tilt meter measures the angle of the down-tilt of the antennas. • The angle between the base plate and the axis of the inclination (angle) is measured in degrees. • The output should be proportional to the sine of the angle of tilt.	 *Fig. 2.4.3 Tilt Meter*

Digital Camera • The Digital Camera is an indispensable part of the EMF survey process. • It helps in documenting the photograph of the site. • The photographs are used as reference points, and it aids in ensuring the validity of the site planning.	 *Fig. 2.4.4 Digital Camera*
Safety Kit • The safety Kit is the box containing essential first aid components. • In case of emergency, a safety kit comes handy to avoid a devastating outcome. • A safety kit is a mandatory inclusion for all towers/ shelters, where workers have to deal with electrical components.	 *Fig. 2.4.5: Safety Kit*
Measuring Tape • Engineers use a measuring tape to measure the distance of the surrounding buildings from the tower. • Measuring tapes are also used to calculate the height of the antenna. • The measuring tape is widely used to measure the bandwidth of the antenna.	 *Fig. 2.4.6: Measuring Tape*

2.4.2 Drive Test Tools

The Drive Test Engineer must arrange the tools and equipment required for performing site audit and drive. The following table lists the various test and measuring equipment:

Name of the Equipment	Function
Laptop 	• The laptop is portable and handy, especially easy to carry to remote places. • Laptops are used to keep track of documents/ data/ information. • Various software or applications are easily accessible through a laptop. • Laptops can be connected to the internet easily, and thus, information sharing, conference calls, and video calls are possible from remote places through the laptop.

Name of the Equipment	Function
Charger/Portable Charger 	• Chargers are used to give charges to the laptop (in case of AC charger) or mobiles (phone charger). • Chargers are portable and can easily be carried from one place to another. • The Power bank is a device that can be charged previously, and the charge gets stored in the power bank. If there is no power point, the power bank helps charge electrical gadgets.
Data Cable 	• Data cable refers to the USB cables which is used for data transfer. • Data can be transferred from laptop to mobile or from mobile to laptop via data cable. • A data cable can also be used as a charger (if one end of the data cable is connected to the laptop and the other end to the mobile phone, the mobile gets charged).
TEMS Dongle 	• It is the standard tool for troubleshooting, verifying, optimising and maintaining wireless networks. • Supports all major technologies. • It is a complete, cost-effective and compact solution.
Mobile Phone 	• The mobile phone has become indispensable in any sector, not only as a medium of communication but also as a handy device which can potentially replace a laptop. • Smartphones enable various features, including facilities like GPS monitoring, calculator, and network provider. • In case a tower is located at a remote place where population and transport are very low, a mobile phone can establish a connection with the metropolitan or the centres in urban areas.

Table 2.4.1: Drive test tools

2.4.3 Drive Test Measurement and Recording Software

The drive test engineer must ascertain the availability and proper installation/configuration of drive test measurement and recording software, such as MAPINFO and MCOM.

MapInfo

MapInfo is a desktop geographic information system (G.I.S.) software product produced by Pitney Bowes Software and MapInfo Corporation and used for mapping and location analysis. MapInfo allows users to visualise, analyse, edit, interpret, understand and output data to reveal relationships, patterns, and trends. MapInfo allows users to explore spatial data within a dataset, symbolise features, and create maps.

- Raster G.I.S. analysis.
- Data creation & editing.
- Resulting sharing.
- Visualisation options.
- Location intelligence suite.

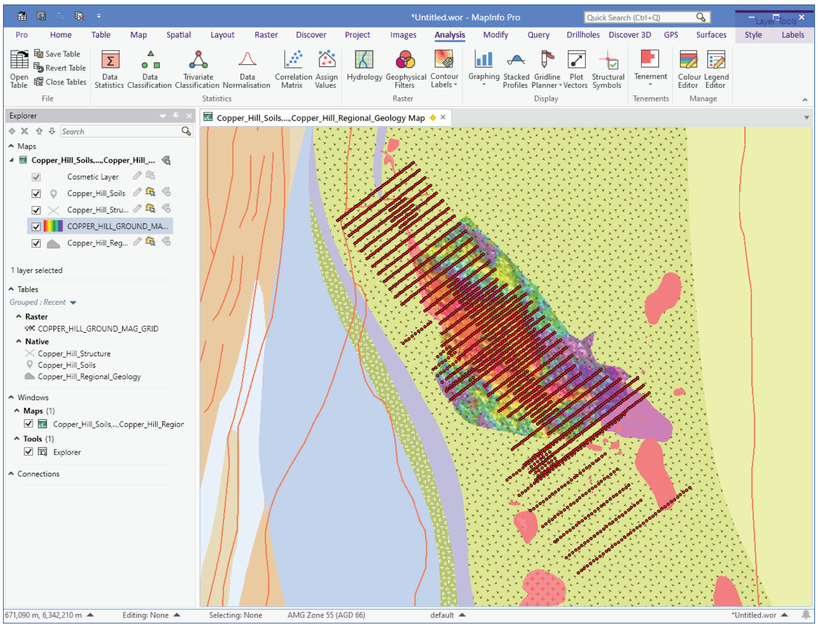

Fig. 2.4.7: MapInfo User Interface

In the telecom sector,

- MapInfo is used to produce coverage maps, plan for additional coverage, and visualise gaps in coverage.
- Maximise probable investment based on demographics, available real estate and local terrain for cell tower sites.

Map Info tool also helps in:

- Locating the position of a tower
- Calculating network congestion of certain locality
- Predicting outages owing to network failure or coverage issues
- Apprehending possible locations for tower installation

The following figure shows a sample of MapInfo layout with the fans in the diagram representing the towers and the colours depicting the coverage strength of the towers:

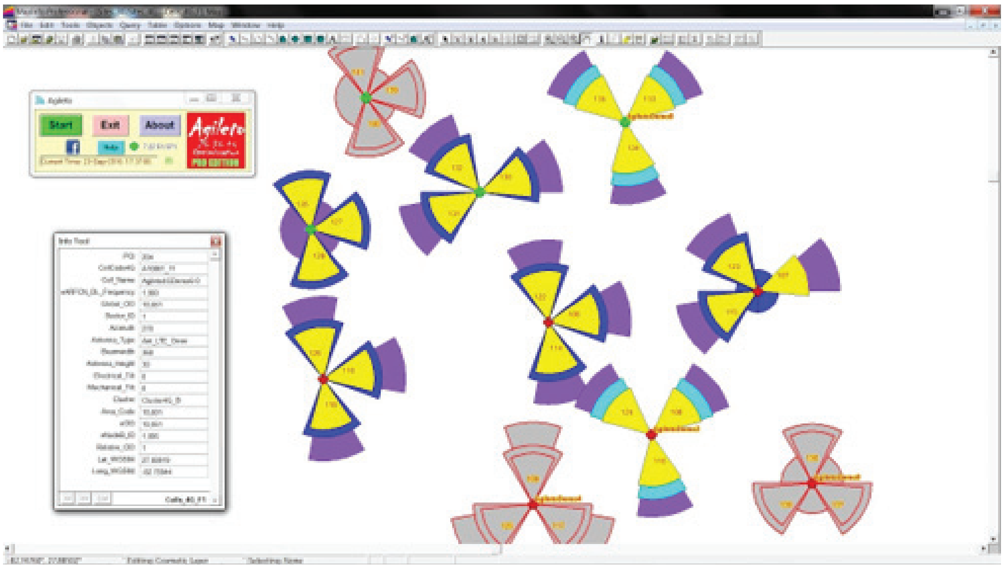

Fig. 2.4.8: Cell Sites in MapInfo

Mobile Communications Network Application (MCOM)

MCOM is a Map-basic application tool that helps in designing a graphical representation of the mobile network in MapInfo.

MCOM's features can be classified into the following group:

- Cell-Planning Tools
- Drive Test Analysis Tools [GSM only]
- STS Analysis Tools

Cell Planning Tools

The features of cell planning tools are as follows:

- Multi-vendor and multi-technology support
- Automatic Frequency Planning (AFP)
- Automatic Cell Planning (A.C.P.)
- Integrated G.I.S. platform (no need for external applications)
- Integrated planning of the area, point-to-multipoint and point-to-point systems
- Backhaul and backbone planning
- Google Earth integration (export of sites, endpoints, links and predictions)
- Drive test integration
- Accurate and advanced propagation models, with the capability of integrating multiple clutter types, heights and resolution layers

The following figure shows a sample layout of cell planning:

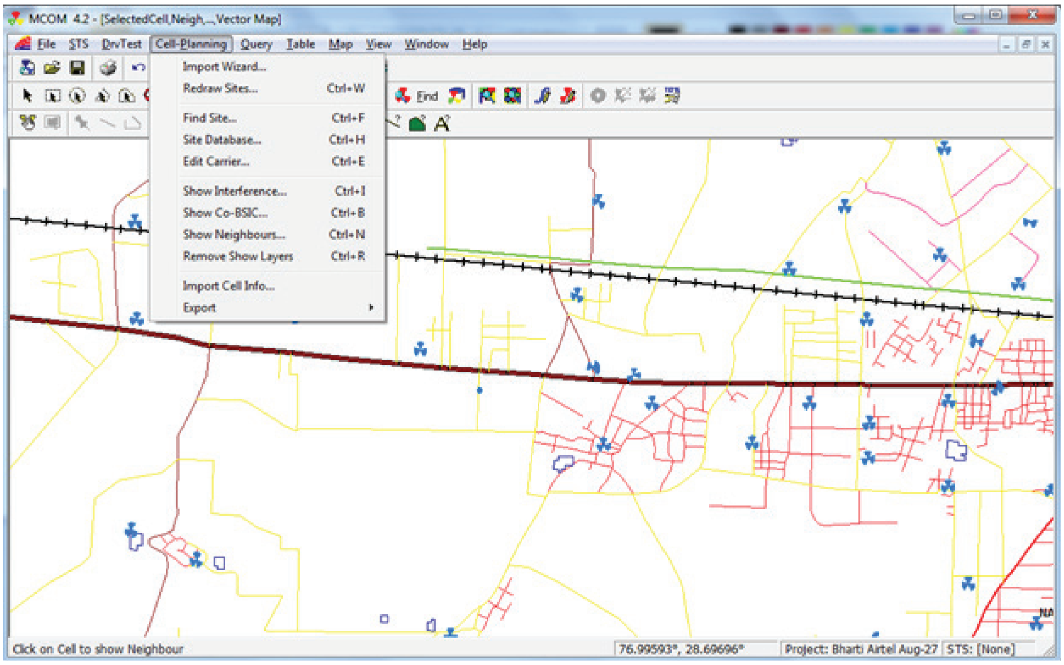

Fig. 2.4.9: MCOM Tool used for site planning

Drive Test Analysis Tool (GSM Only)

The latest versions of MCOM provide an all-in-one box Drive Test Analysis tool to assist in drive test analysis based on TEMS logs. This feature is currently available for GSM TEMS logs only.

The features of the Drive Test Analysis Tool are as follows:

- Drive test must support the capture of G.P.S. information along the drive route
- Must support 2G, 3G, 4G LTE and 5G N.R. measurements
- Data testing such as HTTP, latency and FTP speed tests
- Voice and SMS testing must be supported
- Enabled with Cell Lock / Band Lock feature
- Video streaming testing support on mobile networks will be an added advantage
- Frequency scanning function for all R.A.N. technology
- Layer 3 and Layer 2 messaging capture capabilities if R.F. deep diagnosis information is required
- Script-based call and data session manual and automatic should be available
- RF Tool must be portable; measurement software on a smartphone will be ideal
- Real-time upload of test data to post-processing tool
- The post-processing tool must support the analysis of data on a map-based view
- Post-processing tool should provide graphical and tabular reports for various GSM / UMTS/LTE related network performance features
- The post-processing software tool must work on normal windows-based P.C., or a web-based interface will be ideal
- The system must support the export of excel, maps or PDF-based reports
- Any 5G MIMO measurements will be ideal for verifying during the S.S.V. stage

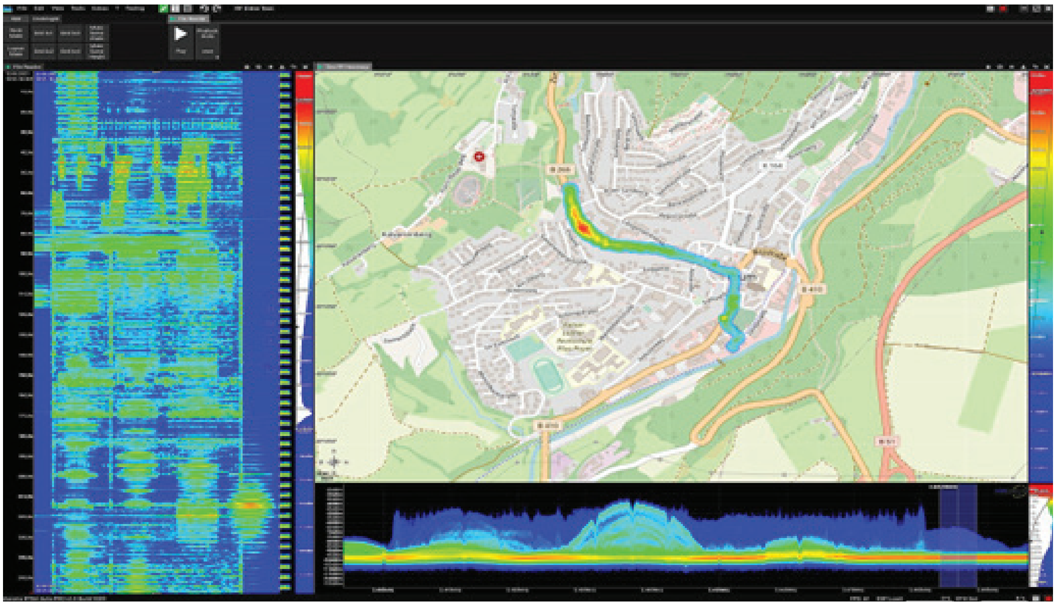

Fig. 2.4.10: MCOM used as Drive Test Analysis Tool

Practical

This activity is in the form of Chart Paper Preparation.

Pre requisite for Practical

- The trainer will divide the class into 4 groups
- The trainer will ask each group to prepare a chart on the following topic:
  "Types of Antenna and Their Radiation Pattern"

Demonstration

- Each group will come up with chart papers which should include:
  - Information
  - Diagram/ Images
  - Radiation pattern analysis
  - Table of comparison between the radiation
- Each group will get an hour to prepare the chart
- After an hour, the trainer will ask the trainees (groups) to stop

Post Demonstration

- The trainer will check the chart papers prepared by each group.
- The best performers will be appreciated by the class.

Summary

- Transmitting and receiving individual signals over a common individual path using synchronized switches connected at either end of the transmission link.
- Prior to the introduction of Pole Towers, Lattice Towers were widely installed. Even today, one can find many lattice towers, especially in rural areas and hill stations.
- Types of antenna used in cell towers based on functionality – Omnidirectional and Directional Antenna
- Modern handsets provide the facility of G.P.S. tracking, which gives more accurate information about the caller's location; thus, TowerID tracking is gradually becoming obsolete.
- Antenna tilt is the angular position of the antenna, which determines the approximate downward angle of the antenna.
- Orientation refers not only to set the antenna in the correct direction but also to setting an accurate down tilt.
- Distributed generation systems are used to provide electricity during power outages, including those that occur after severe storms and during high energy demand days.
- PIU (Power Interface Unit) converts A.C. power supply (3 phase) to 230 volts of A.C.
- The Drive Test Engineer must arrange all the tools and equipment required for performing a site audit and drive test.
- MapInfo is a desktop geographic information system (G.I.S.) software product produced by Pitney Bowes Software and MapInfo Corporation and used for mapping and location analysis.

Exercise

MCQ

1. ______________________ are used to transmit/receive in any direction.

   a) Omnidirectional Antenna   b) Directional Antenna

   c) Both (a)and (b)   d) None of the above

2. Yagi antenna is a ______________________

   a) Omnidirectional Antenna   b) Directional Antenna

   c) Both (a)and (b)   d) None of the above

3. The line running from North to South through Greenwich, England, is known as the ___________________.

   a) Equator   b) Prime Meridian

   c) Latitude   d) None of the above

4. As per the general law of antenna height, the height of the antenna should be ________________ the magnitude of the wavelength.

   a) ½   b) ¼

   c) 2x   d) None of the above

5. MapInfo tool also helps in:

   a) Locating the position of a tower

   b) Calculating network congestion of a particular locality

   c) Predicting outages owing to network failure or coverage issues

   d) All of the above

Descriptive Question

1. What is the use of a Tilt Meter?
2. What are the advantages of passive infrastructure sharing?
3. What are the passive infrastructure on the tower site?
4. How to check antenna Azimuth?
5. What is a Cell Sectors?

Notes

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=uZClGRSJuyE

Telecom Tower

https://www.youtube.com/watch?v=1KeQzZcFoRI

Types of Antennas

https://www.youtube.com/watch?v=5FAp5RnGvu0

Perform E.M.F. Survey as per the Company Norms

https://www.youtube.com/watch?v=BR_W7IjjlvA

Passive Infrastructure on Tower Site

Skill India
कौशल भारत - कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

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National
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3. Tower Site Performance Measurement and Parameter Recording

Telecom Sector Skill Council

Unit 3.1 - Pre-requisites for Drive Test (TEMS)

Unit 3.2 - Conduct Drive Test

Unit 3.3 - Record Faults on Sites Visited

Unit 3.4 - Perform Handover Drive Procedure and Benchmark Test

TEL/N6238

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Demonstrate how to plan area, routes & schedule for conducting drive test
2. Perform drive test on tower site
3. Conduct fault identification and rectification
4. Analyse the clockwise and anti-clockwise handover drive procedure
5. Record and evaluate the parameters captured during the drive test

UNIT 3.1: Pre-requisites for Drive Test (TEMS)

Unit Objectives

By the end of this unit, the participants will be able to:

1. Illustrate the basics of the drive test
2. Identify the appropriate setting and tools required to perform the drive test
3. Identify all the parameters related to 2G drive test
4. Identify all the parameters related to 3G and 4G drive test
5. Describe the use of multiplexer

3.1.1 Drive Test Procedure

Drive Test is the method to perform a test while driving a bicycle, motorcycle, or any other vehicle. The most important things are the software and the hardware used in the test. The following things are essential to performing a drive test:

Notebook with collecting software installed	Secirity Key	Dongle	Mobile Phone
GPS	Scanner (optional)	Adapter/Hub for interconnecting the equipment	

Fig. 3.1.1: Drive Test Pre-requisites

The purpose of a drive test is to gather data. The data can also be viewed/analysed live (real-time) during the test, to get a view of on-site network performance. Information from all units is classified by collection software and recorded in output files.

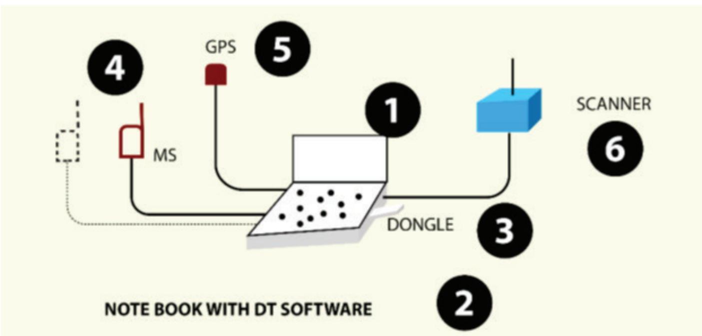


Fig. 3.1.2: A specimen of a proper drive test set-up

Important Terms Related to Drive Test

- **GPS:** GPS is used for data collection of the longitude and latitude of each measurement/ point, such as
  - Data
  - Time
  - Speed

It also acts as a guide that displays the correct routes.

- **MS:** MS is used to collect mobile data such as signal, best server, and strength.
- **Scanner:** Scanner is used to collect data throughout the network since the mobile radio is limited and does not manage all the useful data for a complete analysis.

The following figure shows the essential equipment required for drive test:

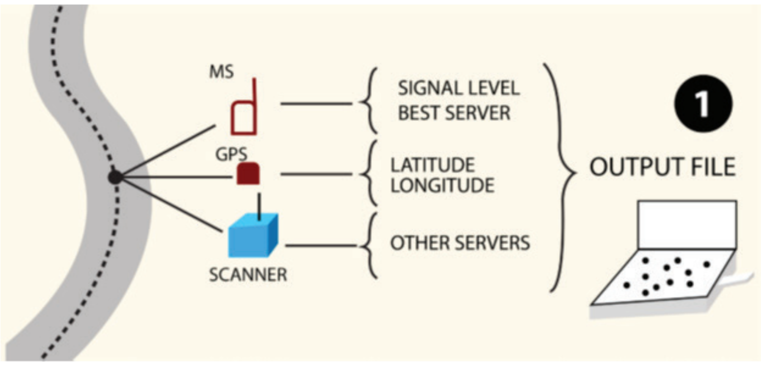


Fig. 3.1.3: Essential equipment for drive test

The following table shows the active network equipment:

Component	Description
BTS 	BTS or Base Transceiver Station comprises of the radio equipment and an antenna to communicate with a Mobile Station. Each BTS covers a specific or predefined zone (coverage area), known as a cell.
Microwave 	Microwaves are used for point-to-point communication because their small wavelength allows conveniently-sized antennas to direct them in narrow beams, which can be pointed directly at the receiving antenna. This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do

Component	Description
IF Cable 	Intermediate Frequency (IF) is a frequency at which a carrier wave is propagated as an intermediate step in reception or transmission. IF cable is used for three major reasons: • IF cables are helpful at very high (gigahertz) frequencies, where signal processing circuitry performs poorly • It is also used in receivers that can be tuned to a range of various frequencies, to convert the different frequencies of the stations to an identical or common frequency for processing • An intermediate frequency improves frequency selectivity by separating components of a signal or extracting signals which are close

Table 3.1.1: Active Components

Nodes

NodeB	Node B is a telecommunications node, to be more specific, in mobile communication networks that broadly fall under the UMTS category. Node B establishes the connection between mobile phones or users (UEs) and the network coverage or the wider telephone network.
eNodeB	eNodeB (eNB) is often referred to as the evolved Node B. It is a component of the E-UTRAN of the LTE network. eNB is attached to the mobile phone network and communicates wirelessly with handsets (UEs).

Table 3.1.2: Active Components

In simpler words, the core elements, such as BTS, BSC, MSC, and Antennas, are active components. Other than these elements, the elements which are used to elevate the performance of the active components are passive components, as a whole, passive infra. Antennas are also active components.

3.1.2 2G Parameters

The following parameters are related to 2G drive test:

Rx Level

Receiver Level (Rx Level) measures the strength of the signal that is received by a mobile phone from a BTS, commonly termed the “mobile tower”.

Rx Level measured in decibel-milliwatt (dBm). It is calculated by the power referenced to one milliwatt (mW). The value of one milliwatt is 10 x log [P(W) / 1mW].

EIRP

Effective/ Equivalent Isotropically Radiated Power (EIRP) measures the power radiated by an antenna to generate the peak power density observed in the direction of maximum antenna gain.

Path Loss

Path Loss refers to the distance between the source of the signal and the antenna (where the signal gets captured). In technical terms, the source of the signal is the transmitting point of the signal, and the antenna is the receiving point of the signal. The distance between the transmitting and the receiving points of the signal is inversely proportional to the strength of the received signal. As the path loss increases, the signal strength decreases.

The mathematical formula to calculate Rx Level is:

Rx Level - EIRP - Path Loss

The Rx Level is always a negative value as the numeric value of the EIRP is always less than the numeric value of Path Loss.

For example,

Path Loss = 25 decibel

EIRP = 15 decibel-milliwatt

Rx Level = EIRP – Path Loss = 15 – 25 = -10 decibel-milliwatt

Rx quality is the average signal strength quality coming from the serving cell. Rx quality is calculated over the time slots and the subset of the time slots. In the case of hopping, the numeric value of Rx quality should be less than 5; without hopping, it should be less than 4.

Carrier over Interference ratio (C/I)

The ratio between the level of the signal strength (of the serving cell) and the signal strengths of the impedimental components is known as C/I. In Path Loss, various other components will emit an array of signals considered interference to the main signal.

Generally, C/I is updated in every two seconds.

The following table shows the status of different C/I outputs:

C/ I Output	Status
25 – 15	Good
15 – 9	Fair
Less than 9	Bad

Table 3.1.3: Status of different C/I output

Speech Quality (SQI)

SQI refers to the Speech Quality of a call. It reflects the quality of speech (as opposed to radio environment conditions). SQI is the parameter to check when troubleshooting the quality of speech of a call under question.

SQI is updated in every 0.5 seconds.

Good SQI output: 18 to 30

Bad SQI output: 0 to 18

3.1.3 3G Parameters

The following parameters are related to the 3G drive test:

Received Signal Code Power (RSCP) is the strength of a signal received by a receiver from a specific physical communication channel. It indicates the signal strength of a signal and helps to measure the Path Loss of that particular signal. RSCP is often termed as Receiver Side Call Power.

Ec/No indicates the clarity and quality of a signal from the cell tower to the handset or modem. It is measured as the signal-to-noise ratio (the ratio between the good/ received signal and the bad/ interference signal). The unit of measurement of Ec/No is decibel.

Ec/No = Received Signal Strength/ Interference Signal strength

In a perfect (arbitrary) scenario, where no interference occurs in the path loss, the numerical value of the Ec/ No is 0 decibel. However, this is an ideal scenario and mostly hypothetical. If the value of the Ec/ No is more than 7 decibels, the signal's connection or quality is considered poor.

Factors that can affect Ec/ No are:

- Buildings
- Walls
- Power supplies
- Shortened connectors
- Inaccurate antenna alignment
- Wrong antenna polarization
- Florescent lighting
- Electric motors
- Bad/poor cabling
- Trees
- Hills
- Congestion at the tower

3.1.4 4G Parameters

The following parameters should be properly analysed for the drive test of 4G or VoLTE:

- Reference Signal Receiver Power (RSRP)
- Reference Signal Receive Quality (RSRQ)
- Signal to Noise Ratio (SINR)
- Physical Cell Id (PCI)
- Uplink (UL) / Downlink (DL) throughput
- MO/MT
- AT/DT
- Ping testing

3.1.5 Multiplexer (MuX)

A multiplexer or MuX is a combination of logic gates that selects and forwards several analogue or digital input signals into a single line by applying control signals.

Multiplexers are used to increase the amount of data that can be sent over the network within a certain amount of time and bandwidth.

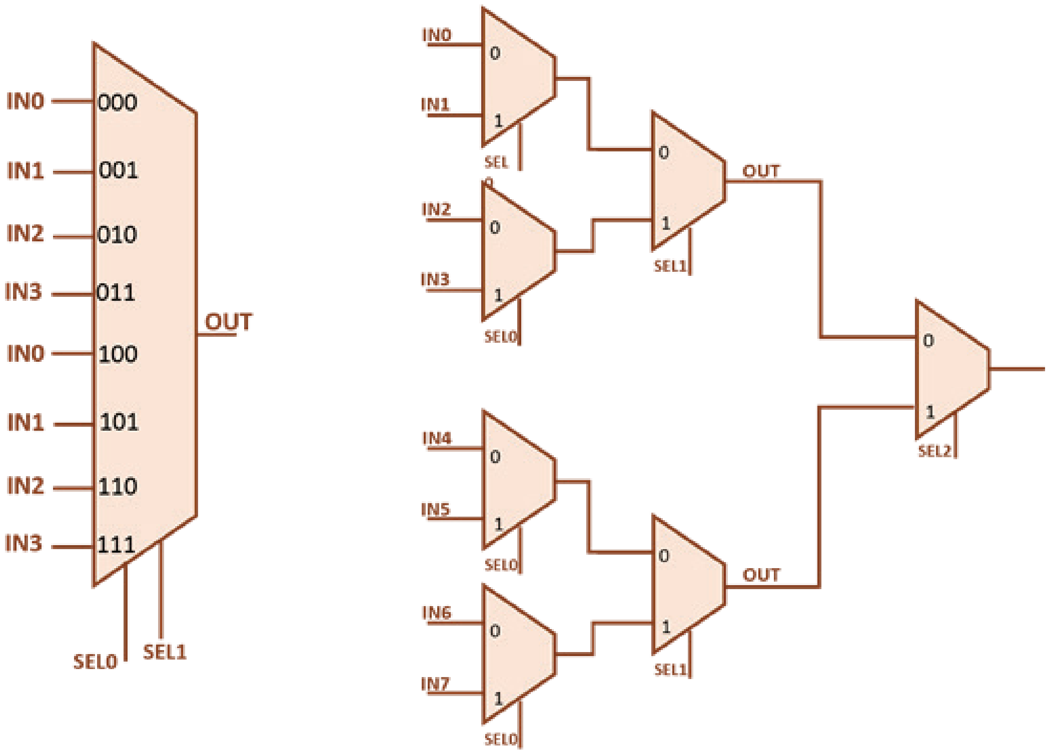


Fig. 3.1.8: 3 Input Multiplexer

UNIT 3.2: Conduct Drive Test

Unit Objectives

By the end of this unit, the participants will be able to:

1. Analyse the route of the site for the drive test
2. Demonstrate the process of generating a performance report (log file) based on the drive test

3.2.1 Planning Route and Schedule

Drive test in telecom is the best possible solution for mobile network operators (CSPs) to collect signal strength, mobile network latency, voice call KPIs etc., along with GPS coordinates and constantly improve the network.

The first step of performing a drive test is to set the route testing will take place. The routes are predetermined or planned in the office before stepping into the site of testing. A program that helps a lot in outlining the path for drive testing is Google Earth. The routes are traced on Google Earth using easy paths or polygons. The drive test engineer is given the final image or output. The following figure outlines the drive test route on a map.

Fig. 3.3.1: Drive Test Route

When to conduct a drive test?

Drive testing can be conducted during both the day and night. It is dependent upon the operator's requirements and subscriber habits.

Drive test during the day will replicate the conditions as seen by subscribers but may clog up the network if call analysis is done.

Drive testing during the night allows a greater area to be surveyed due to the reduction in vehicular traffic and will also allow for certain test signals to be tested, specially when setting up a new cell site, with minimal interruption of usual operation.

However, night-time testing does not replicate the conditions experienced by subscribers. For planning purposes, a drive test is usually performed at night, and for maintenance purposes, drive testing is done during the day.

3.2.2 Construction of Drive Test Log Files

A Drive Test Log file is a detailed report of the test based on some predetermined parameters. The main aspects of the drive test log file are:

- BCCH of serving cell and neighbours
- Hopping Information - HSN, frequencies
- Time Slot
- Timing Advance
- CGI - MCC, MNC, LAC, CI
- RxLev of serving cell and neighbours
- BSIC of serving cell and neighbours
- Channel type/mode
- Radio Link Timer

date_time	latitude	longitude	signal_level	best_server	...
10/03/2011 23:54	37.379242	-122.088951	-85.56	115	...
11/03/2011 23:55	37.379242	-122.088951	-86.63	115	...
12/03/2011 23:56	37.379242	-122.088951	-86.62	115	...
13/03/2011 23:57	37.379242	-122.088951	-84.9	115	...
14/03/2011 23:58	37.379234	-122.088973	-89.5	89	...
15/03/2011 23:59	37.379234	-122.088973	-84.76	37	...
17/03/2011 00:00	37.379211	-122.088988	-86.02	63	...
24/03/2011 00:07	37.379176	-122.088592	-85.92	115	...
25/03/2011 00:08	37.379188	-122.088469	-80.81	89	...
26/03/2011 00:09	37.379246	-122.088336	-72.8	37	...
...	...	...	...	...	...

Fig. 3.3.2: Drive Test Log File

Essential laptop configuration required for drive test

Perform the following steps:

1. **Power Management:** Set the "Power Management Laptop" option on:

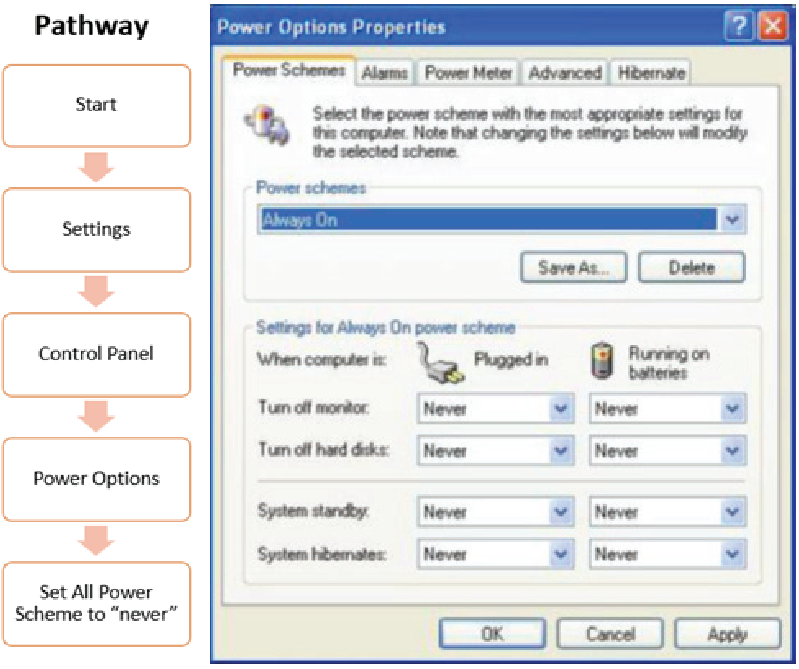


Fig. 3.3.3: Power option configuration page

2. **Virtual Memory:** Set the virtual memory on:

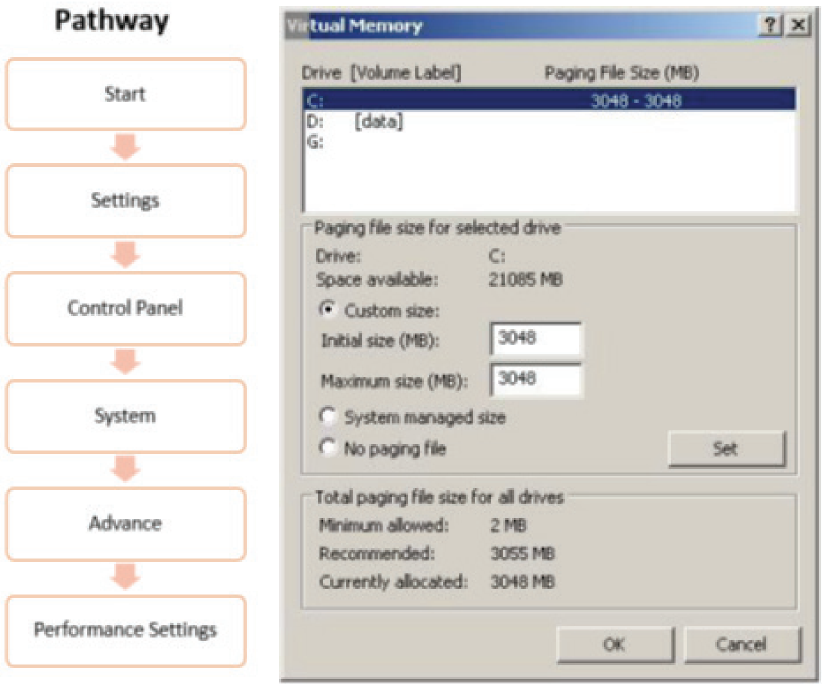


Fig. 3.3.4: Virtual memory configuration page

3.2.3 Aspects documented in a drive test log file

Dropped Calls: Call drop happens when your phone gets disconnected somehow from the cellular network. Generally, this happens because of poor cell signal wherever you are, which causes the call to drop.

Blocked Calls: A blocked call is a telephone call that is unable to connect to an intended recipient. The prime reason for this could be that the system connecting the call is busy or the system has been programmed to block calls after it has reached its capacity.

Handover failures: In cellular telecommunications, handover, or handoff, is transferring an ongoing call or data session from one channel connected to the core network to another. Handover failures are unavailable time slots because of high traffic, congestion, low signal strength or bad quality on the target cell. Handover can fail due to hardware issues in target cells – more likely TRX or time slot problems. If the handover attempt fails, MS tries to return to the old channel.

Clockwise and anti-clockwise handover drive

There are two types of handovers performed during the Drive Test of a BTS – Co-channel Handover and the Neighbor channel handover. The Co-channel handover is the way to handoff the call-in other cells of the BTS from the one cell of the same BTS. It is performed to watch the frequent handover capacity of the same BTS.

Let us assume a BTS and the serving cell is A, B, C. for the co-channel handover. We have to hand off the call in a particular sequence, like from A to B, then B to C and C to A, like the clockwise way.

Next, we have to maintain the sequence in an alternative way, which means the anti-clockwise way that is from A to C, C to B, and then B to A. After this step, the handover mechanism is compleated.

3.2.4 Generate Performance Report

A Drive test is carried out to measure the signal strength of specific areas. Like every test, report generation is an integrated part of the drive test.

The steps to generate the test report are as follows:

Step 1:
- Open TEMS Data Collection
- Start → TEMS Products → TEMS Investigations 6.1.4 Data Collection

Step 2:
- Menu Tab
- Logfile → Report Generator

Step 3:
- Add logfile

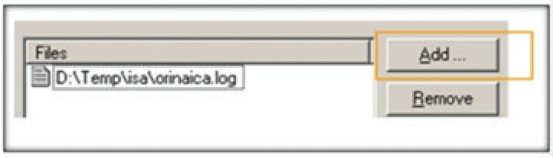


Fig. 3.3.5: Add log file

Step 4:
- Setup Output directory

Step 5:
- Setup Report properties

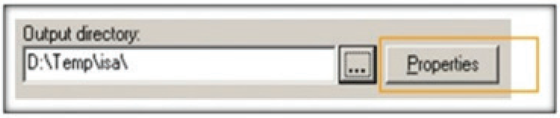


Fig. 3.3.5: Properties setting page

Step 6:
- Setup IEs, Events, Mobiles and User Details

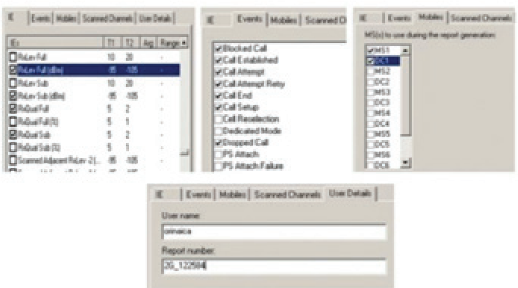
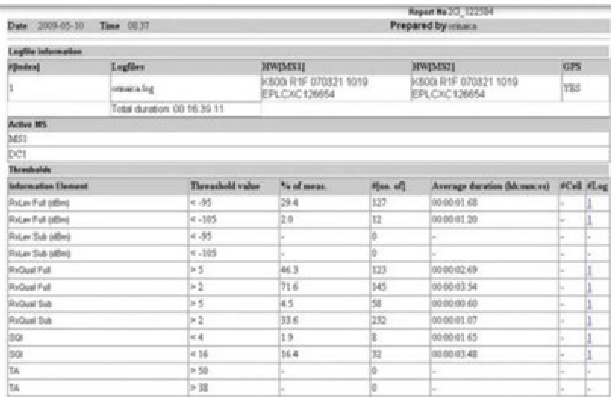


Fig 3.3.6 User details page

Step 7:
- View the result of Report Generator in *.htm



Report No 2G_122584

Date 2009-05-30 Time 08:37 Prepared by orinaica

Logfile information

#[Index]	Logfiles	HW[MS1]	HW[MS2]	GPS
1	orinaica.log	K600i R1F 070321 1019 EPLCXC126654	K600i R1F 070321 1019 EPLCXC126654	YES
	Total duration: 00:16:39.11			

Active MS

MS1

DC1

Thresholds

Information Element	Threshold value	% of meas.	#[no. of]	Average duration (hh:mm:ss)	#Cell	#Log
RxLev Full (dBm)	< -95	29.4	127	00:00:01.68	-	1
RxLev Full (dBm)	< -105	2.0	12	00:00:01.20	-	1
RxLev Sub (dBm)	< -95	-	0	-	-	-
RxLev Sub (dBm)	< -105	-	0	-	-	-
RxQual Full	> 5	46.3	123	00:00:02.69	-	1
RxQual Full	> 2	71.6	145	00:00:03.54	-	1
RxQual Sub	> 5	4.5	58	00:00:00.60	-	1
RxQual Sub	> 2	33.6	232	00:00:01.07	-	1
SQI	< 4	1.9	8	00:00:01.65	-	1
SQI	< 16	16.4	32	00:00:03.48	-	1
TA	> 50	-	0	-	-	-
TA	> 38	-	0	-	-	-

Fig 3.3.7 Final report of the Drive test

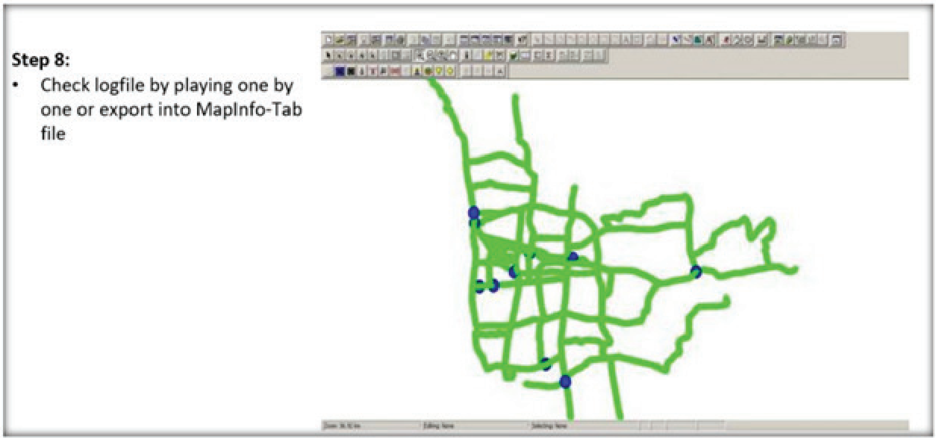


Fig. 3.3.8 Check the logfile by playing it one by one or export into MapInfo -Tab file

Check the log files before leaving the site.

- The Log file is a detailed report/analysis of the findings of the drive test performed in specific areas. Thus, this should be rechecked before leaving the site to ensure that the readings are accurate.
- Log files are used as a document for future reference. Therefore, wrong data/information in the log file will hamper the drive tests taken in future.
- Log files are referred to frequently at the time of troubleshooting. It should contain absolutely accurate and error-free information to ensure fruitful troubleshooting.

The following image shows the inside of a drive test vehicle while conducting a drive test:

Fig. 3.3.9: A picture taken while conducting drive test

UNIT 3.3: Record Faults on Sites Visited

Unit Objectives

By the end of this unit, the participants will be able to:

1. Analyse the process of recording faults and taking corrective actions
2. List the methods of filling in a drive test report template
3. Evaluate the process of generating the performance report

3.3.1 Record Faults

The purpose of technical documentation is to:

- Gauge the root cause of an issue
- Measure the extent of the issue
- Apprehend the possible/ probable causes
- Perform proper troubleshooting steps to resolve the issue
- Ensure that the issue does not get repeated
- Use the entire process (documentation) as a reference for future

Identify the fault and rectify the issue on the site. If the issue cannot be resolved, then it needs to be escalated to the superior.

The process of sharing the feedback or the technical documentation follows the telecom hierarchy. For example:

- Junior engineers are usually assigned the job of a site visit and performing the first level of troubleshooting.
- If the issue gets resolved, the junior engineer(s) will send a report documenting the cause of the issue and explaining the troubleshooting steps performed.
- The report should contain the apprehension or forecast about the reoccurrence of the issue if the issue is “partially resolved” or a “stop-gap measurement” has been taken to resolve the issue.
- The report must comprise the issue details and the last date the same issue had occurred
- The junior engineer should follow a written communication with the senior technicians and engineers through email.
- The email should comprise of the points mentioned above and the remarks of the junior engineers who have visited the site to resolve the issue.

A typical scenario is the **disorientation of the antenna at a cell tower**, which has caused weak signal strength or inadequate coverage with frequent call drops.

Disorientation of the antenna may happen due to:

- Storm or heavy wind
- Unmindful set-up of the antenna
- Distortion or displacement caused by birds or animals

Technical Documentation (Drive Test Report)

The following figure shows a sample template for technical documentation:

Troubleshooting Report			
Date of Troubleshooting	Cause of the Issue	Troubleshooting Action Taken	Remarks

Description of the Issue:

Last Date of Occurrence (of the issue):

Signature of the Jr. Engineer (Onsite Engineer)

Signature of the Sr. Engineer

Fig. 3.4.1: A typical template for listing faults and reporting them

UNIT 3.4: Perform Handover Drive Procedure and Benchmark Test

Unit Objectives

By the end of this unit, the participants will be able to:

1. Analyse the clockwise and anti-clockwise handover drive procedure
2. Identify the nature of the fault
3. Evaluate the value of coordination with other technicians
4. Analyse the reasons behind the issues
5. Evaluate the drive test procedures
6. Discuss the significance of the drive test

3.4.1 Perform Handover Drive Procedure

A Drive test is carried out to check the coverage criteria of the tower site. The data or information collected by drive test tools in the form of Log files is examined to evaluate different RF parameters of the network.

The below list shows the network parameters such as:

- Coverage area
- Indoor and Outdoor coverage
- Speech Quality
- Interference
- Call drops in the network

Optimization is performed in the network to:

- Minimize the rate of call drops and RF interference in the network
- Increase indoor and outdoor coverage
- Attain better speech quality

Identify the nature of the fault

The fault in a network can arise due to active or passive components at the tower site. The fault can be on the nature of:

- Call drop
- Blocked call
- Handover failure

Call Drop

Call drop had become one of the major issues in 2017, especially in urban or populated areas. It became a national topic, and the situation led to a campaign called #NoCallDrops (organized by Network 18).

The involvement of various authorities like Dot, TRAI, PMO and the Indian Telecom Ministry improved the situation. According to the TRAI, the call drop percentage should be less than two. Only two calls may get dropped in 100 calls. However, the scenario in India was worse than that. Another crucial aspect of dropped calls is the monetary loss of subscribers. If a call gets dropped within the first few seconds of the call, the subscriber has to pay a charge for the full minute.

For example, the subscriber will pay for the minute if a call gets dropped within 5 seconds. TRAI proposed financial compensation for subscribers suffering from call drops frequently. This could be a quick solution; however, on the other hand, it is nothing but a stop-gap arrangement.

Handover Failures

Handover failures take place mostly while the user is roaming. When a subscriber travels from one place to another, the BTS of the cell network changes. In simpler words, when a person travels out of their allotted tower, the network provider switches the BTS from the allotted tower to a neighbouring tower. This fact is referred to as the handover of the cell tower. Due to technical glitches, handover may suffer failure, resulting in frequent call drops or inadequate network coverage.

Blocked Call

A blocked call is almost similar to the call drops, and however, there is little difference between them.

- Calls are registered as blocked when a call fails to reach the conversation state.
- On the other hand, a dropped call reaches the conversation state but fails to survive through the entire call time (desired by the caller).

The possible reasons for call drop, handover failures and blocked calls.

- **Poor Network Coverage:** Poor network coverage is an outcome of various factors.
  - **Underdeveloped Tower Infrastructure:** Cell tower plays a pivotal role in transmitting and receiving signals. Every call gets received by the tower antenna and then routed to the proper destination. If the cell tower is weak and underdeveloped, the lack of technical arrangement may cause frequent call drops due to the tower's incompatibility.
  - **Improper Network Setting/ Planning:** We have already discussed the sectors and the role of antennas in receiving and transmitting calls. Now, if sectors get swapped more often, or the antenna placement suffers from poor planning, the result will be inevitable drops of calls. For example, if the antenna is not set up to the accurate height with proper downtilt, it will not be able to receive the signals correctly. Similarly, sector swaps make the network coverage poor and incompetent.
  - **Lack of Optimisation of the Network:** Optimisation refers to the ideal set-up of a network for the best possible coverage. Constant scrutiny, or in other terms, drive tests and various other minor and major troubleshooting, should be performed to have the network up and running smoothly. For example, networks suffer from lightning and rain. In rainy seasons, network towers should be kept under constant vigilance to avoid major outages. Lack of optimization plans ultimately results in major outages. The aftermath includes no network, inadequate coverage and frequent call drops.
- **Overloaded Cell Towers:** The number of subscribers is multiplying. We have already read the information about it in the introductory unit. Now, thinking about the case from the perspective of a network site will give a brief idea about one of the significant reasons for call drops.

  The number of smartphone users has grown astonishingly high in the last few years due to less expensive handsets and services. However, this has caused overloads to cell towers. Assume an area had 45 smartphone users in 2015. The cell tower used to cater to these 45 subscribers in 2015. By 2018, the number of subscribers has increased to 132. The same tower has to provide service to 132 subscribers now. So, a considerable jump in the number of subscribers from 45 to 132 has overloaded the cell tower. After reaching the state of saturation, the tower is bound to malfunction. That means if the tower can cater to 100 subscribers, and if it has to provide service to 132 subscribers, it will take a heavy toll on the tower. Therefore, the lack of capacity will result in call drops.

- **Change in the Cityscape:** The rise in the population calls for tall or multi-storeyed buildings to offer accommodation to a maximum number of people in a relatively small space. Building construction has become necessary and a business engaging huge amounts of transactions. Therefore, it is not so easy to stop constructing buildings. However, if a building is constructed in such a way that it is between the path of the signal between the source of the signal and the cell tower receiving the signal, it acts as an impediment. Impediments make the signals weak and, at times, do not allow the signals to reach the cell tower. There have been cases reported saying construction of new buildings has caused the loss of cell reception for the adjacent buildings/ housings. Constant vigilance and drive tests are the only way to avoid this situation. Proper data analysis would help the technicians in coming up with plans to nullify call drops due to this reason.
- **Handover Failures:** Handover failures take place mostly while the user is roaming. When a subscriber travels from one place to another, the BTS of the cell network changes. In simpler words, when a person travels out of his/ her allotted tower, the network provider switches the BTS from the allotted tower to a neighbouring tower. This fact is referred to as the handover of the cell tower. Due to technical glitches, handover may suffer failure, resulting in frequent call drops or poor network coverage.
- **Technical Glitches:** Towers are equipped with various tools and instruments, minute and gigantic. A cell tower works perfectly when all these tools work harmoniously. However, technical failure is something that one cannot control. Especially, electrical tools are susceptible to faults and failures more frequently compared to other instruments. Thorough monitoring is the only way to avoid a calamitous outage due to a technical fault.

Undertake/coordinate root cause analysis

Call drops, blocked calls and handover failure are all technical issues and call for experts to resolve them. The drive test team must coordinate with the infra engineers or the technicians to eliminate the issue.

- The drive test team collects data based on which the engineers find out the root cause of the issue.
- The task of the drive test team is to collect and analyse data, whereas the engineers work based on the analysis to resolve the issue.
- The task of the engineers is to perform technical troubleshooting to resolve the issue, and the drive test team provide all the necessary document and analysis to the engineers to narrow down an issue.
- The drive test team covers a huge area, analysing and collecting data from it. On the other hand, the technical team works at the tower to fix the issues.

3.4.2 Perform Benchmark Test

Network benchmarking is essential to maintain quality standards for telecom operators.

Record Faults

Network Benchmarking:

- Regulators perform Drive Test to monitor the quality-of-service standard against the Key Performance Indicators (KPIs).
- The KPIs agreed on with the operators.
- The operators, therefore, go through Benchmarking activity

Below are some of the KPIs analyzed in Network Benchmarking

Voice Services

- Packet Data Protocol(PDP) context Activation/Deactivation
- Radio Link Control (RLC) Throughput Uplink/Downlink
- Data Latency
- Successful connection rate to the Internet
- Maintaining an Internet session
- The Holding time of session
- Average settlement period of an Internet connection
- Failure rate of an FTP connection

Data Services

- Packet Data Protocol(PDP) context Activation/Deactivation
- Radio Link Control (RLC) Throughput Uplink/Downlink
- Data Latency
- Successful connection rate to the Internet
- Maintaining an Internet session
- The Holding time of session
- Average settlement period of an Internet connection
- Failure rate of an FTP connection

Fig. 3.5.1: Some of the KPIs analysed in network benchmarking

Each KPI component is measured minutely, and the output is compared to that of the competitors. Customized analysis is conducted to provide the operator with a better picture of varying KPI values owing to dependencies that can be utilized for root cause analysis and performance improvement. The following figure shows a comparison of MOS value with C/I distribution:

Speech Version	< 6	12 to 15	6 to 9	9 to 12	>= 15	Avg. MOS
Fill Rate	2.0	2.8	2.6	3.2	3.2	2.8
Half Rate	2.7	2.9	2.6	2.6	3.0	2.8
Grand Total	2.5	2.9	2.6	2.7	3.1	2.8

Table 3.5.1: MOS value compared with C/I distribution

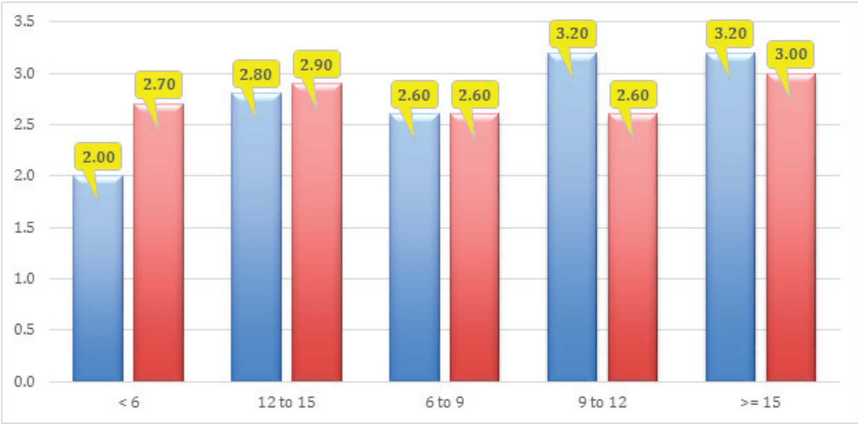


Fig. 3.5.2: Comparison bar of MOS value compared with C/I distribution

Cluster Optimization Test

- Minimum of 20 to 30 eNB's
- Contiguous coverage
- Can cross TA boundaries

Test Entrance Criteria

- At least 80% of the eNB's in the test cluster shall have passed SCFT and complied with EMF norms.
- SCFT and EMF compliance report for each eNB for the test cluster has to be verified.
- Any changes to the eNB physical Configuration required for EMF compliance shall be updated in the cluster database.

The following figure shows a typical cluster optimization test:

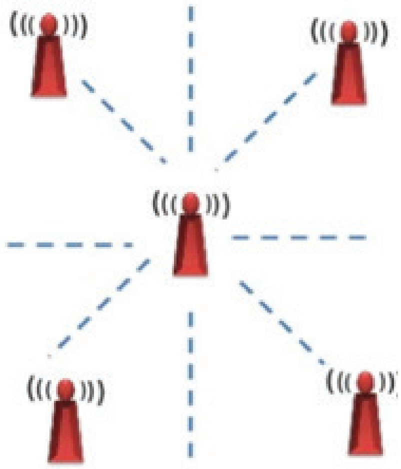


Fig. 3.5.3: Cluster optimization test

Summary

- Drive Test is the method to perform a test while driving a bicycle, motorcycle, or any other vehicle.
- The purpose of a drive test is to gather data which can be viewed/analysed live (real-time) during the test, to get a view of on-site network performance.
- Multiplexers are used to increase the amount of data that can be sent over the network within a certain amount of time and bandwidth
- Drive test in telecom is the best possible solution for mobile network operators (CSPs) to collect signal strength, mobile network latency, voice call KPIs etc., along with GPS coordinates and constantly improve the network.
- Drive testing can be conducted during both the day and night. It is dependent upon the operator's requirements and subscriber habits.
- Call drops, blocked calls and handover failure are all technical issues and call for experts to resolve them

Exercise

MCQ

1. Optimisation is performed in the network to:

   a) Minimise the rate of call drops and RF interference in the network

   b) Increase indoor and outdoor coverage

   c) Attain better speech quality

   d) All of the above

2. The ratio between the level of the signal strength and the signal strengths of the impedimental components is known as________________

   a) Carrier over Interference ratio (C/I)   b) Rx quality

   c) EIRP   d) None of the above

3. __________________________ is a combination of logic gates that selects and forwards several analogue or digital input signals into a single line by applying control signals.

   a) Switch   b) Multiplexers

   c) Hubs   d) None of the above

4. BTS stands for:

   a) British Telecommunication System   b) Base Transmission Sector

   c) Base Transceiver Station   d) None of the above

5. SQI is updated in every ______________________seconds.

   a) 0.5   b) 60

   c) 30   d) None of the above

Descriptive Question

1. When to conduct a drive test?
2. What is NodeB?
3. What is Speech Quality (SQI)
4. What are the factors that affect Ec/ No?
5. What is ‘Handover failure’?

Notes

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Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=v-IkGJzLq1k

Drive Test Procedure

https://www.youtube.com/watch?v=Gk52a2USRbo

Construction of Drive Test Log Files

https://www.youtube.com/watch?v=o0xfNslYl1A

Perform Handover Drive Procedure

https://www.youtube.com/watch?v=KoopqvkPXdo

Perform Benchmark Test

Skill India
कौशल भारत-कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

4. Tower Site Data Analysis and Reporting

Telecom Sector Skill Council

Unit 4.1 - Perform Tower Site Data Analysis

Unit 4.2 - TEMS Software for Site Data Analysis

TEL/N6239

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Analyse the tower site report generated by the drive test tool
2. List the network parameter checks
3. Identify the features of TEMS software
4. Demonstrate how to use TEMS software for drive testing

UNIT 4.1: Perform Tower Site Data Analysis

Unit Objectives

By the end of this unit, the participants will be able to:

1. Analyse the tower site report generated by the drive test tool
2. Analyse the 4G parameters

4.1.1 Tower Site Data Analysis

Analysis of the report generated by a drive test tool represents the true picture of the network conditions. This analysis is used in making decisions in a number of areas, right from planning and design to optimization and maintenance of the system.

The following tower site data parameters are analysed after collecting data through a drive test:

- Rx Level
- Rx Quality
- Frame Error Rate (FER)
- Bit Error Rate (BER)
- Speech Quality Index (SQI)
- C/I
- MS Power Control Level
- Discontinuous Transmission (DTX)
- Timing Advance (TA)
- Radio Link Timeout Counter
- MAIO
- BCCH
- BSIC
- CGI
- HSN
- Hopping Frequency
- Band
- Ciphering Algorithm

4.1.2 Network Parameter Checks

BTS

A Base Transceiver Station enables wireless communication between user equipment (UE) and a network. UEs are devices like mobile phones (handsets), WLL phones, and computers with wireless Internet connectivity. The network can be any of the wireless communication technologies like GSM, CDMA, wireless local loop, Wi-Fi, WiMAX or another wide area network (WAN) technology.

NODE B, eNODE B (eNB) and G NODE B

BTS is also referred to as node B (in 3G networks) or, simply, the base station (BS). For discussion of the LTE standard, the abbreviation eNB for evolved node B is widely used, and GNodeB is for 5G.

Though the term BTS can apply to any wireless communication standards, it is generally associated with mobile communication technologies like CDMA and GSM.

In this regard, a BTS forms part of the Base Station Subsystem (BSS) developments for system management. It may also have equipment for encrypting and decrypting communications, spectrum filtering tools (bandpass filters), etc. Antennas are also considered as the components of BTS in the general sense as they facilitate the functioning of BTS. Typically, a BTS will have several transceivers (TRXs), which allow it to serve several different frequencies and sectors of the cell (in the case of sectorised base stations). A parent base station controller controls a BTS via the Base Station Control Function (BCF). The BCF is implemented as a discrete unit or incorporated in a TRX in compact base stations. The BCF provides an operations and maintenance (O&M) connection to the network management system (NMS) and manages the operational states of each TRX, software handling and alarm collection. The basic structure and functions of the BTS remain the same regardless of the wireless technologies.

Transmit Power

Transmit power is the amount of power input into the signal to a device. The traditional model of radio planning relies on radio-frequency (RF) measurement, RF surveys and drive tests to determine the transmit power (TX power), antenna azimuth and tilt. The TX power has a very high influence on the inter-cell interferences and on the network coverage because the LTE and 5G use the same frequencies in all cells.

During the network's lifetime, these parameters need to be adapted, e.g. when a new cell is added in a nearby location. This is not feasible for a network consisting of many small cells, as the cost of the RF planning and reconfigurations may be a significant part of operational costs. Moreover, modern cellular networks have become more dynamic, with new base stations added to the network in response to increased load to maximize resource reuse. Normally a 4G base station transmission power is 43dBm, and base station transmission power for 5G can range from 24dBm (small cells) to 50dBm (for MIMO).

Frequency hopping

Frequency hopping is a technique that improves the uplink performance by providing frequency diversity and interference averaging in the 3G LTE uplink.

To enhance the performance of radio communication systems, it is crucial to mitigate the challenges presented by interference, noise, and the inherently dynamic nature of the radio channel. One of the techniques that can be used to mitigate the effects of fading and interference is frequency hopping. Different forms of frequency hopping have been used in different technologies.

Similarly, different techniques that provide uplink diversity can be used when channel-dependent scheduling is unsuitable. Hopping in frequency can be performed on PUSCH (Physical Uplink Shared Channel) - the channel on which the user data is transmitted. Thus frequency hopping in the uplink can be called PUSCH frequency hopping. 3GPP specifies two types of frequency hopping for the LTE uplink, Type 1 PUSCH Hopping and Type 2 PUSCH Hopping.

Type 1 PUSCH Hopping: The scheduling grant provides the hopping information in the first type of hopping. Thus it can be called “hopping based on explicit hopping information in the scheduling grant”

Type 2 PUSCH Hopping: In Type 2 PUSCH hopping, the hopping bandwidth is virtually divided into sub-bands of equal width. Each sub-band constitutes several contiguous resource blocks.

4.1.3 4G/VOLTE Parameters

Reference Signal Receiver Power (RSRP)

RSRP is one of the fundamental physical layer measurements of the handset.

Mobile networks perform cell selection or reselection and handover when a mobile device moves from one cell to another. So, it has to measure the signal strength or quality of the neighbour cells. In this course of handover, the flexibility of using RSRP is specified by the LTE networks. RSRP is a Received Signal Strength Indicator (RSSI). RSRP is the power of the LTE Reference Signals, which are spread over the full bandwidth and narrowband.

The linear average power of the downlink reference signals (RS) across the channel bandwidth for the Resource elements bears cell-specific Reference Signals. RSRP) is measured in decibel-milliwatt.

The mathematical formula to measure RSRP is:

RSRP (dBm) = RSSI (dBm) -10*log (12*N)

Where,

- RSSI – Received Signal Strength Indicator
- N – number of RBs across the RSSI

The features of RSRP are as follows:

- RSRP provides vital information about the strength of cells from which path loss can be measured to the UE.
- It is used in the algorithms for obtaining the optimum power settings for managing the network.
- It is used both in idle and connected states.
- Range of RSRP value is from -44dBm to -140dBm

Fig. 3.1.4: Features of RSRP

Reference Signal Receive Quality (RSRQ)

Reference Signal Received Quality is also the key measure of signal level and quality for LTE networks. Its quality is also considered based on RSSI. The number of Resource Blocks used is:

(N) RSRQ = (N * RSRP) / RSSI measured over the same bandwidth

RSRQ indicates the quality of the received reference signal. RSRQ measurement gives additional information when RSRP is insufficient to make a reliable handover or cell reselection decision.

Where,

- N – number of resource blocks over which the RSSI is measured
- RSSI – wideband power, including intra-cell power, interference, and noise

RSRQ is used only during connected states.

Measuring RSRQ becomes specifically important near the cell edge when decisions ought to be taken to carry out a handover to the next cell.

Range of RSRQ value is from -3 to -19.5 dB

Fig. 3.1.5: Features of RSRQ

Signal to Noise Ratio (SINR)

SINR is a process to measure the quality of LTE wireless connections. The energy of the signal dissolves with distance (Path Loss) due to environmental impediments (interfering strength of other simultaneous transmissions, background noise).

The mathematical formula to measure SINR is:

SINR = S / I + N

Where,

- S – Average Received Signal Power
- I – Average Interference power
- N – Noise Power

Physical Cell Id (PCI)

The physical cell ID (PCI) is an indicator of the physical layer identity of the cell. The PCI is used for cell identity during the selection. PCI optimization, to a great extent, is done to ensure that neighbouring cells should have different primary sequences allocated. It is the most important cell identifier in the 4G and 5G mobile networks.

The mathematical formula to measure PCI is:

PCI = PSS + 3 x SSS

Where,

- PSS – Primary Synchronization Signal (Identifies Cell Id)
- PSS – can be 0, 1 and 2
- SSS – Secondary Synchronization Signal (identifies Cell Id group).
- SSS – can be 0 to 167

The ideal range for PCI is: 0 to 503

MO/MT

MO stands for Mobile Originated. This type of message refers to a message sent from a mobile phone, which the customer/subscriber sends from a mobile phone to mobile marketing and mobile SMS provider through the SMS.

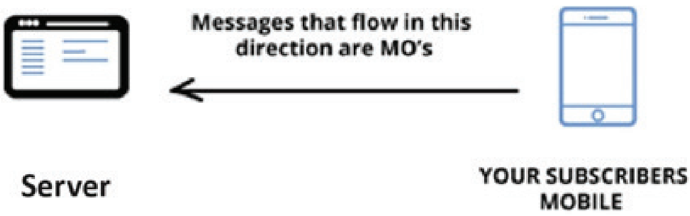

Fig. 3.1.6: MO messaging

MT stands for Mobile Terminitted which is very similar but the inverse of MO. This type of message flows from an SMS gateway to a smartphone, mobile device or cell phone. It is a mobile message routed from a client or an application and delivered to the end user's mobile phone is called an SMS MT (Mobile Terminated). Terminated means the message is delivered on a mobile device. It is also known as an Outbound SMS.

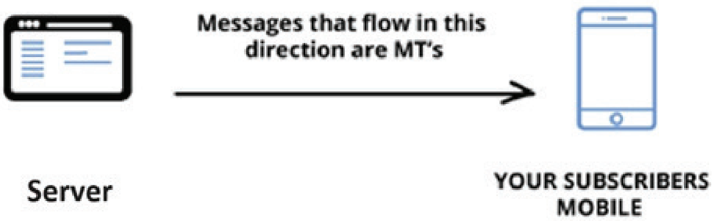

Fig. 3.1.7: MT messaging

UL/DLThroughput

It refers to the separation of uplink and downlink transmissions so that downlink data is received from the higher power macro nodes, whereas uplink data may be transmitted to closer located pico nodes.

The downlink receives throughput through the Physical Downlink shared channel (PDSCH). The PDSCH is used to transfer application data in the downlink.

In Downlink, Physical Downlink Control Channel (PDCCH) is an important channel of the eNodeB which contains all information related to the control region in the Downlink and Uplink Scheduling information.

The Uplink channel which carries control signalling is the Physical Uplink Control Channel (PUCCH).

Some Important Telecommunication Links

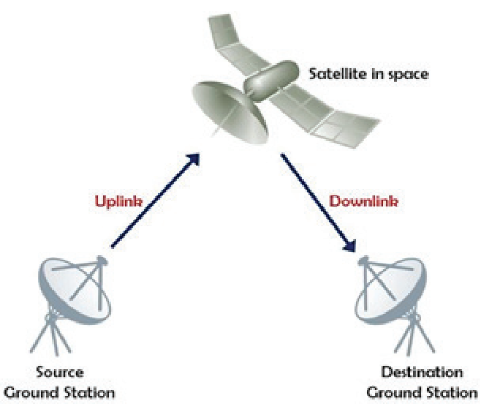	**Uplink** The Uplink (UL or U/L) is the transmission path of the signal from the mobile station to a base station.
	Downlink Downlink (DL or D/L) is the transmission path of the signal from the base station to a mobile station.
	Forward Link Forward Link is the link from a fixed location (i.e. a base station) to a mobile user

Table 3.1.4: Telecommunication Links

T1/ E1

T1, also known as Digital Signal 1 (DS1), is a North American specification for a dedicated 1.544 Mbps telephone line. T stands for terrestrial in the T1. It can transmit up to 24 calls simultaneously over a single line.

The T1 data stream is broken into several frames. Each frame consists of a single framing bit and 24 8-bit channels, totalling 193 bits per T1 frame. The frames are transmitted 8,000 times per second at a data transmission rate of 1.544 Mbps.

E1 is the equivalent European digital transmission format of the DS1. An E1 offers dedicated 2.048 Mbps and can simultaneously carry 32 voice calls of 64 Kbps each. E1 links have higher bandwidth than the T1 links because they use all 8 bits of a channel, whereas the T1 links use 1 bit in each channel for overhead.

Both T1s and E1s carry DS1 signals and can interconnect with each other globally.

Ping Test

A ping (Packet Internet or Inter-Network Groper) is a basic Internet program that allows to test and verify if a particular destination IP address exists and can accept requests in computer network administration.

A ping test method is used for checking if the computer is connected to a network. It also determines the latency or delay in the network. A ping test is run for troubleshooting to know connectivity as well as response time.

UNIT 4.2: TEMS Software for Site Data Analysis

Unit Objectives

By the end of this unit, the participants will be able to:

1. Identify the features of TEMS software
2. Explain how to use TEMS software for drive testing

4.2.1 Test Mobile System (TEMS)

Test Mobile System (TEMS) is a technology used by telecom operators for measuring, analyzing and optimizing their mobile networks. It is the industry standard tool for performing wireless network drive testing, benchmarking, monitoring and analysis. It supports all major technologies and is used in more than 180 countries worldwide.

TEMS allows the drive tester to test every new feature and function in the network.

Workspace Configuration

After installation of TEMS software, open TEMS Investigation.

All Programs → TEMS investigation → Data Collect

The following screenshot shows an example workspace:

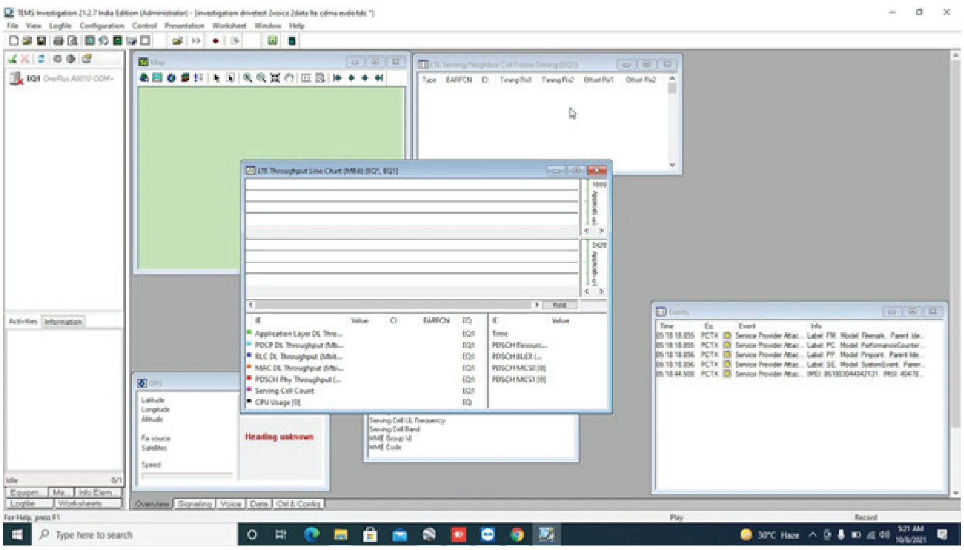

Fig. 4.2.1: TEMS Investigation Interface

The steps and pathway to configure Workspace in TEMS are as follows:

Step 1. Open Worksheet Map and arrange the size of the window Map

Step 2. GPS (Presentation → Positioning → GPS)

Step 3. Port Configuration (Configuration→ Port Configuration)

Step 4. Command Sequence (Control → Command Sequence)

Step 5. Serving + Neighbours GSM (Presentation → GSM→ Serving + Neighbours GSM)

Step 6. Current Channel (Presentation → GSM → Current Channel)

Step 7. Event (Presentation Signalling → Events)

Generating performance report

Setting a map or creating the path outline for the drive test activity plays a significant role. We have already discussed the vitality of outlining the path and the impediments of outlining the drive test path. In this unit, we will discuss the same from the perspective of the TEMS software, i.e., the configuration of the TEMS software for outlining paths of the drive test.

Create Geoset

The steps to create Geoset in TEMS are as follows:

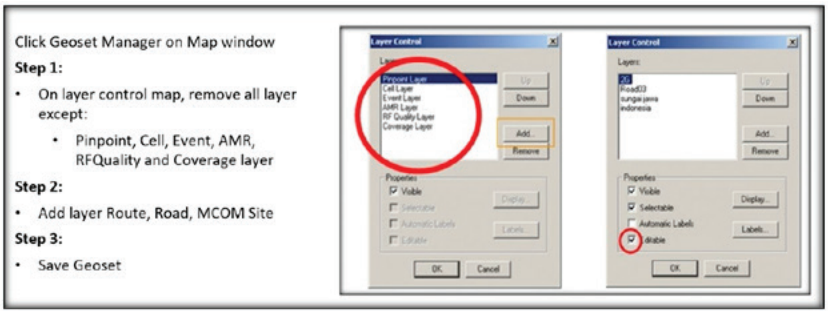

Fig. 4.2.2: Adding layer and configuring layer control in TEMS

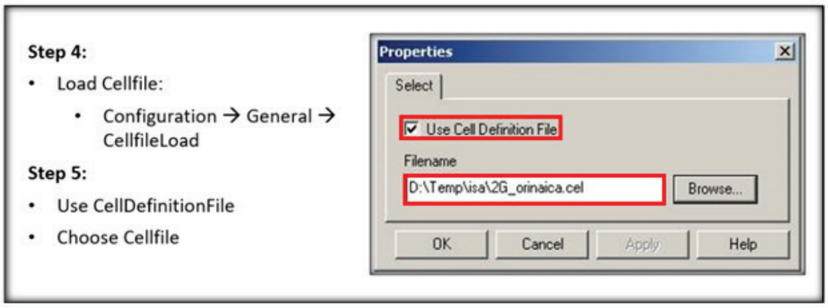

Fig. 4.2.3: Choosing Cell Definition File in TEMS

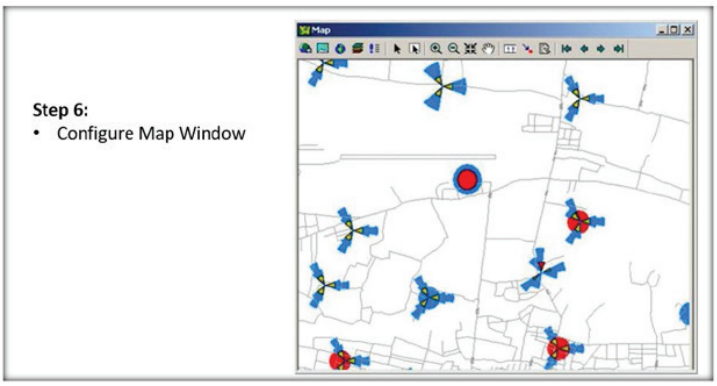

Fig. 4.2.4: Setting up Map Window in TEMS for Drive Testing

Apart fromt these, there are a few other features of TEMS software, such as:

- Allowing porting in of external devices
- Setting up command sequence for drive testing

Drive Testing with TEMS: Steps and Pathways

The steps and pathway for Drive Testing with TEMS are as follows:

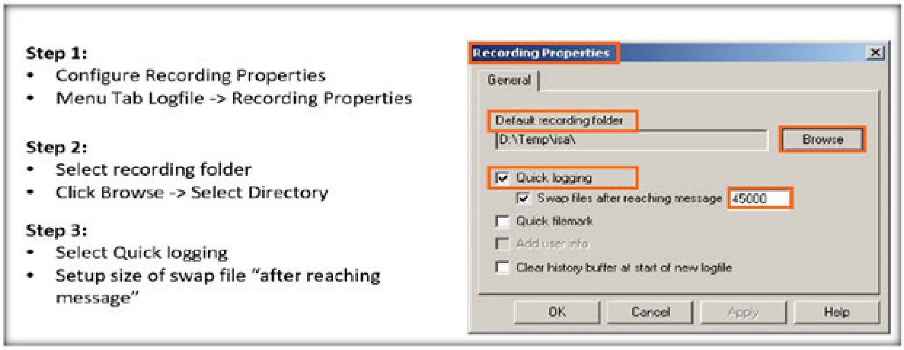

Fig. 4.2.5: Recording in TEMS software

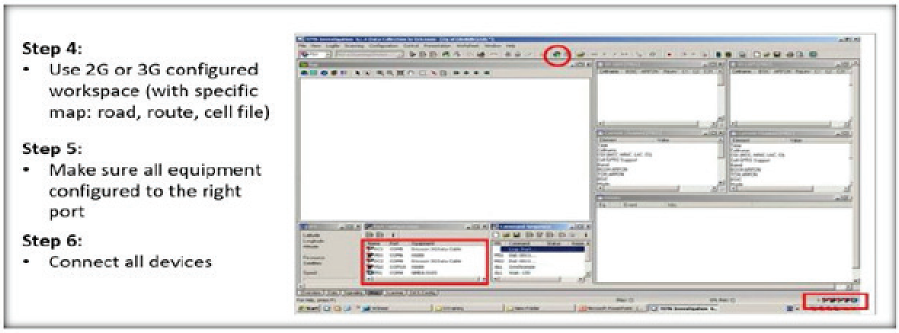

Fig. 4.2.6: Connecting devices through TEMS

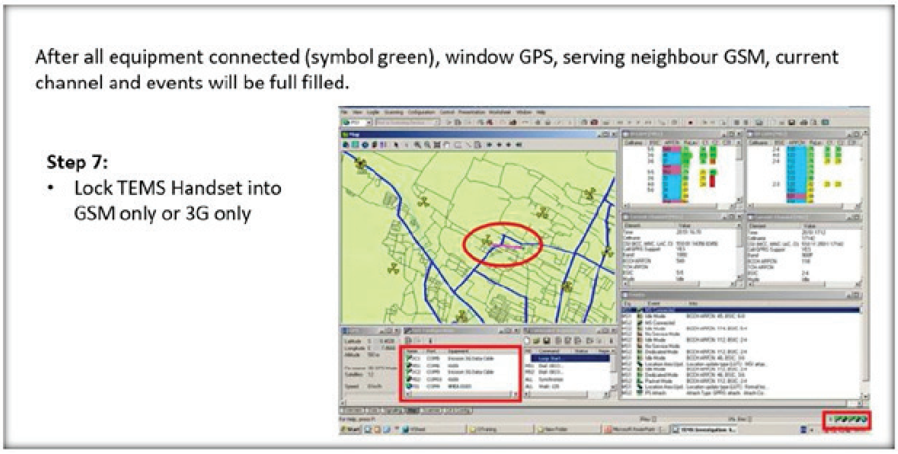

Fig. 4.2.7: Locking TEMS to start drive test

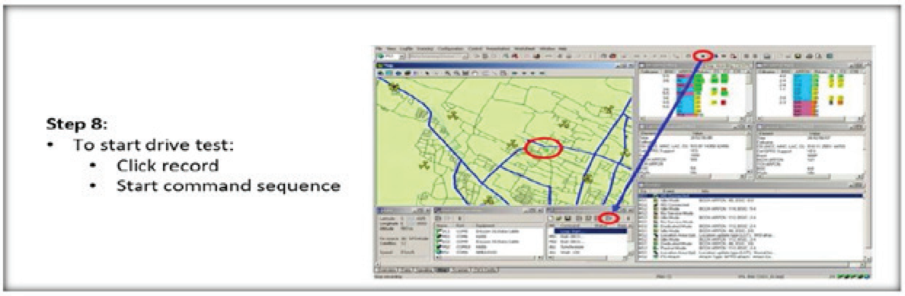

Fig. 4.2.8: Click on the Record button and start Drive Test using TEMS

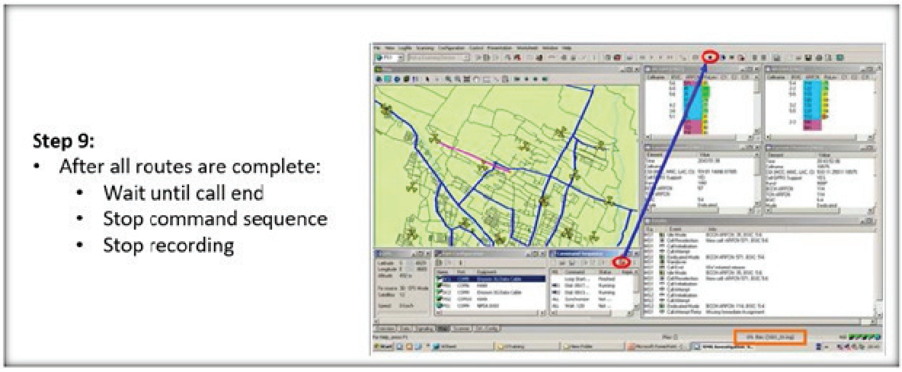

Fig. 4.2.9: Click on Stop Recording to complete the drive test route

The flowchart below shows the sequence of steps of performing the Drive Test using TEMS software:

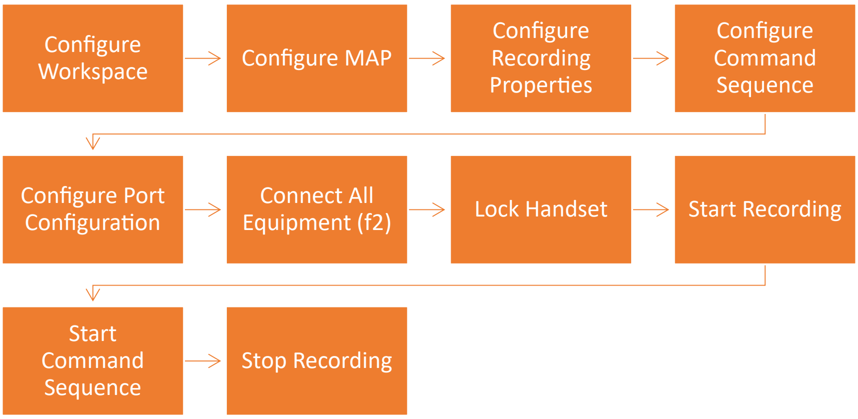

Fig. 4.2.10: Steps of performing Drive Test using TEMS software

4.2.2 TEMS Pocket

TEMS Pocket is a portable mobile application network testing solution supporting 5G scanners and several 5G devices. TEMS Pocket allows you to verify, optimize and troubleshoot your mobile network in environments requiring portability, such as malls, stadiums, offices, and other large venues.

Fig. 4.2.11: TEMS Pocket

TEMS Pocket is a unique device-based testing solution which can be mounted to a drone to help you perform tests in hard-to-reach places.

Summary

- Analysis of the report generated by a drive test tool represents the true picture of the network conditions.
- A Base Transceiver Station enables wireless communication between User Equipment (UE) and a network.
- Transmit power is the amount of power input into the signal to a device.
- Frequency hopping is a technique that improves the uplink performance by providing frequency diversity and interference averaging in the 3G LTE uplink.
- RSRP is one of the fundamental physical layer measurements of the handset.
- A ping test method is used for checking if the computer is connected to a network. It also determines the latency or delay in the network.
- Test Mobile System (TEMS) is a technology used by telecom operators for measuring, analyzing and optimizing their mobile networks.
- TEMS Pocket is a unique device-based testing solution which can be mounted to a drone to help you perform tests in hard-to-reach places.

Exercise

MCQ

1. A ________________is run for troubleshooting to know connectivity and response time.

   a) Ping test　　b) Noise test

   c) Drive test　　d) None of the above

2. In _________________________PUSCH hopping, the hopping bandwidth is virtually divided into sub-bands of equal width.

   a) Type 1　　b) Type 2

   c) Type 3　　d) None of the above

3. RSRP is measured in ________________________

   a) decibel-milliwatt　　b) decibel-kilowatt

   c) decibel-millimeter　　d) None of the above

4. ________________________is when your customers send messages from their mobile phones to your system.

   a) Mobile Terminated (MT)　　b) Mobile Originated (MO)

   c) Both (a) and(b)　　d) None of the above

5. The range of RSRQ values is from _________________________

   a) 2 to 19.5 dB　　b) -3 to -19.5 dB

   c) -1 to 1 dB　　d) None of the above

Descriptive Question

1. What is Frequency hopping?
2. How to calculate Reference Signal Receiver Power (RSRP)?
3. Differentiate between MO and MT messaging?
4. Why is a ping test done?
5. What is Test Mobile System (TEMS)?

Notes

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=pc3rZhgLJdc

Tower Site Data Analysis

https://www.youtube.com/watch?v=6ZhaRyrL9I0

Test Mobile System (TEMS)

5. Tower Site Optimization and Troubleshooting

Unit 5.1 - Basic Troubleshooting Techniques

Unit 5.2 - Evaluate Parameters from NOC and Implement Corrective Actions

TEL/N6240

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Perform troubleshooting of basic laptop, mobile and data card problems
2. Conduct basic troubleshooting of GPS related problems
3. Evaluate the NOC parameters
4. Analyse the method of optimizing tower performance
5. Demonstrate the implementation of corrective actions based on cell performances

UNIT 5.1: Basic Troubleshooting Techniques

Unit Objectives

By the end of this unit, the participants will be able to:

1. Demonstrate the process to troubleshoot Laptop, GPS, Mobile Phone, Software, Dongle

5.1.1 Troubleshooting

Troubleshooting is a systematic approach to finding and resolving an issue instead of restoring normal working conditions. In every sector, troubleshooting plays a pivotal role in elongating the lifespan of devices or modules.

In the case of a drive test, as it deals with electrical components, it requires meticulous inspection and herculean patience to troubleshoot an issue.

The following figure shows the stages of troubleshooting:

Fig. 5.1.1: Stages of troubleshooting

The following table shows the common laptop problems, their symptoms and solutions:

Issue	Symptom	Solution (Troubleshooting steps)
Blurred Display	• Hazy display output • Grains on the screen • Zigzag lines	• Open the laptop case • Check the display connector of the laptop
No Display	• Screen will be absolutely black • While programs/ applications will run, they won't get displayed	• Check the RAM as it might be a cause of no display • Inspect the connector of the laptop responsible for the display • Check the power supply of the laptop, i.e., the SMPS
Not Powering On	• Laptop will not get power on even if it is fully charged	• **SMPS issue:** Check the SMPS • **Laptop battery issue:** Re-insert the battery in the slot (may require alterations in some cases) • **Power switch issue:** Needs repairing

Not Booting	• The laptop will get powered on but not open the OS (Operating System) page
	• Consequently, the applications and software will not get opened
		• Hard Disk issue:
		  o Check the operating system's validity
		  o Try to enter the OS page (e.g., Windows) in Safe Mode
		• Check the Hard Disk cable for proper connectivity (SATA connector)

Slow Net/ No Net (RF Issues)	• The network page is not opening properly • Taking a long time to open a page (buffering issue) • Showing "No Signal"	• Check the access point or Wi-Fi router (measure the distance between the router and the laptop) • In case the distance is much greater than the coverage area of the router, it may result in a slow net or no net at all • Inspect the network adapter (NIC or the Network Interface Card) if the router is working fine (in these cases, the network adapter is unable to capture the packets sent by the router) • Check the network cable for connectivity issues • In the case of buffering issues, contact the ISP (Internet Service Provider) for a better signal

Table 5.1.1: Troubleshooting for Laptops

The following table shows the common mobile phone problems, their symptoms and solutions:

Issue	Symptom	Solution (Troubleshooting steps)
Hanging issues	• Phone gets hung up frequently • Specific applications might get hung while opening	• Restart the mobile • Scan the mobile for virus
Display issues	• Scratch on the display • Blurred or no display	• Reboot the mobile • The display might cause by a hardware issue; thus, consult a technician • Send it to repairing centre
Overheating issues	• The handset gets overheated while using	• Reinsert the mobile battery in the designated slot • Keep the phone unused (inactivate) for a while if the phone has been active for a long period of time • Stop overcharging
Battery Issue (Power Issue)	• Battery might not receive the charge • The charge may get drained out in a very short period • Battery might not receive the charge • The charge may get drained out in a very short period	• Check the expiry date of the battery • Do not overcharge as it may cause decay in the properties of the battery • Check the receptor port of the phone, which is connected directly to the battery

Slow Net/ No Net (RF Issues)	• The network page is not opening properly • Taking a long time to open a page (buffering issue) • Showing "No Signal"	• SIM card issue o Confirm the validity (activation expiry date) of the net pack o Check if the roaming option is ticked in case one is travelling o Confirm if the phone is within the network coverage area • Wi-Fi Issue o Check if the handset is within the Wi-Fi coverage area o In case many users (tenants/ hosts) are sharing the same Wi-Fi, the speed may get reduced o Investigate the Wi-Fi program in the device is in proper working condition o Check the net-sharing combination. If the same is configured incorrectly, net issues may occur

Table 5.1.2: Troubleshooting for mobile phones

The following table shows the common Data Card problems, their symptoms and solutions:

Issue	Symptom	Solution (Troubleshooting steps)
Card not showing	• Pop up appears "There is no space in the card", although space is available	• Restart the phone/ system/ device and try once again • Insert the data card into the computer and scan it • Verify if there is any data available
Data Card got hanged	• Buffering symbol appears on the screen • The symbol does not move nor let the system run another application/ software/ program	• Try to close the application forcefully and restart the device/system/ handset • Try to open the application in safe mode • Check the points of the data connector and reinsert the data card in the designated slot for better performance
Virus/ Phishing/ Spam/ Malware/ spyware/ Adware attack	• Data card gets slow, and performance gets degraded • Various types of applications open randomly without asking for permission before accessing	• Scan the Data Card with proper antivirus • Purchase an antivirus and configure it into the machine/device/system • Avoid those sites which are not secure to protect the data card

Cannot show proper location all the time	• Shows incorrect location on the map (for example, if the device is at point A, a GPS might show the position of the device at point Z)	• Check the device's net connection • Investigate the location (availability of the status of the location on GPS)
Inaccurate direction	• Might show the wrong or inaccurate direction	• The issue might happen owing to the throttled net; in that case, check the coverage area • Reset the net (the aeroplane mode might be "ON", which causes the issue)

Table 5.1.3: Troubleshooting for GPS

UNIT 5.2: Evaluate Parameters from NOC and Implement Corrective Actions

Unit Objectives

By the end of this unit, the participants will be able to:

1. Examine the site optimization parameters at the antenna end
2. Evaluate the NOC parameters
3. Analyse the method of optimizing tower performance
4. Demonstrate the implementation of corrective actions based on cell performances

5.2.1 Tower Site Optimization Methods

The application of technology, particularly wireless communication, is broadly used nowadays. Hence, the devices supporting a telecommunication network are also increased significantly. The telecommunication tower is the main device to provide the telecommunication network for mobile users. As the growth of mobile users grows every year, the needs for telecommunication towers also rise. However, to build the telecommunication tower, some criteria must be fulfilled, such as; area, environment, air space, etc. Therefore, cell planning is required. Cell planning is one of the techniques used to arrange the location of a telecommunication tower, which can be added or reduced by considering the volume.

Optimisation Techniques

Radio communication antennas are a powerful component we can use to improve signal propagation and coverage. An antenna is a specialised transducer that converts radio frequency (RF) fields into alternating current or vice versa. Antennas can transmit and/or receive radio signals. Proper antenna setup and installation can drastically improve radio transmission distance and penetration capability. The following are points about choosing an Antenna:

- Choose the Right Antenna Size
- Select the Right Antenna Type
- Optimize Line-of-Sight
- Clear Obstacles in the Antenna Vicinity
- Orient the Antenna Properly
- Use Low-Loss Connectors and Cables

5.2.2 Antenna Parameters Adjustment for Tower Site Optimization

The antenna parameters adjusted for tower site optimisation are:

- Antenna azimuths
- Antenna tilts (Electrical/Mechanical)
- Antenna height and orientation

1. **Adjust the direction angles of antennas.**

   Direction angles of antennas are adjusted to change the coverage areas of cells. When the direction angles are adjusted by 5° or 10°, there are no big changes. Therefore, direction angles are generally adjusted by more than 10° at 5° intervals.

2. **Adjust downtilt angles of antennas.**

   Downtilt angles of antennas are adjusted to change the coverage radius of cells. The mechanical downtilt angles of antennas are generally adjusted by 0° to 10°. In practice, note that downtilt angles cannot be too large. Otherwise, forward transmitted waveforms may be distorted. Many existing antennas support electrical downtilt, so you can first adjust the electrical downtilt angles of antennas remotely.

   The tilt represents the inclination of the antenna to its axis.

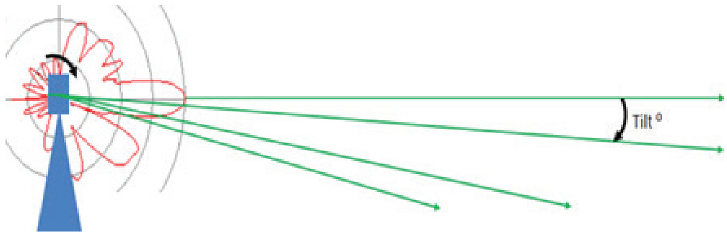

Fig. 5.2.1 Tilt angle

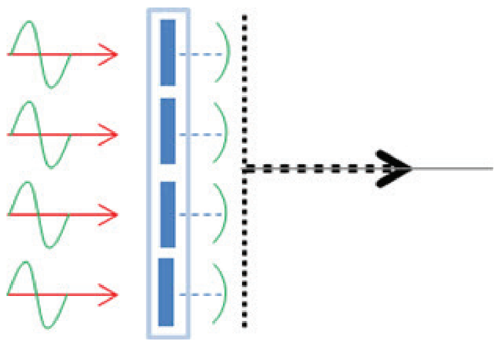

Fig. 5.2.2 Antenna without tilt

There are two types of tilt which can be applied together:

Mechanical Tilt - The mechanical tilt is tilting the antenna, through specific accessories on its bracket, without changing the phase of the input signal

Electrical Tilt - For the electrical tilt, the modification is obtained by altering the characteristics of the signal phase of each element of the antenna

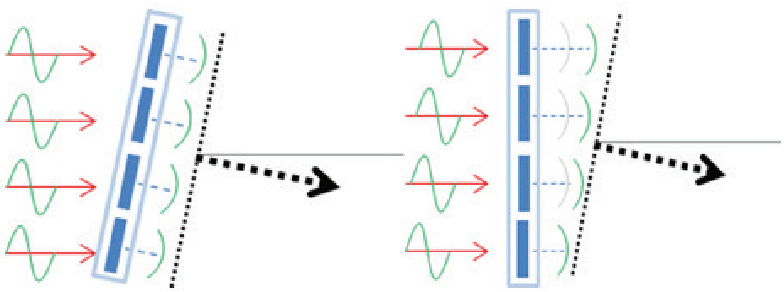

Fig. 5.2.3 Antenna with tilt

Electrical tilt can have a fixed value or be variable, usually adjusted through accessories like a rod or bolt with markings. This adjustment can be either remote or manual, in the latter case being known as 'RET' (Remote Electrical Tilt), which is usually a small engine connected to the screw stem/regulator that does the job of adjusting the tilt.

3. **Adjust antenna heights.**

   This adjustment is mainly for high and low eNodeB. If an eNodeB is in a too high or low place, serious overshoot coverage or insufficient coverage is caused. Suppose the coverage problems cannot be solved after the down tilt angles and direction angles of antennas are adjusted, and mechanical downtilt antennas are replaced with remote electrical tilt antennas. In that case, you can adjust antenna heights or relocate the eNodeB.

5.2.3 Network Operations Centre (NOC)

Network Operations Centre (NOC) is also known as the Network Management Centre. NOC is one or more centres from which network management and control, or network monitoring, is practised over a computer, telecommunication or satellite network.

In telecommunication environments, NOCs are responsible for:

- Investigating power failures
- Communication line alarms such as framing errors, bit errors, line coding errors and circuits down
- Other performance issues which may impact the network
- Prepare track details about the call flow

The following figure shows the setup of a typical Network Operation Centre:

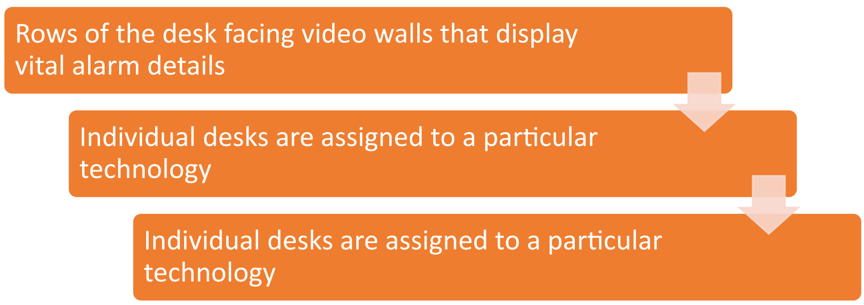

Fig. 5.2.2: Setup of a typical Network Operation Centre

Network Operation Centres handle issues in a hierarchical manner so that if an issue is unresolved in a specific timeline, the next level is informed about pacing up to solve the problem. Most of the Network Operation Centres have multiple tiers, which fabricate the skill of technicians and NOC engineers.

5.2.4 Factors Affecting Signal Propagation

We have already discussed various factors that affect the propagation of the signal from its source to the receiver (cell tower). Let us quickly recall the main reasons for the obstructions:

- Buildings are one of the major obstructions to transmitting signals. The signal tends to weaken if there are tall buildings on the Path Loss (the distance between the source of the signal and the cell tower).
- Buildings or constructions, especially with metallic roofs or shielding, obstruct the signals the most. Metals are the most potent interference to the signals compared to the other materials.
- If the distance between the cell tower and the signal source is too large, the signal is susceptible to losing its strength. Every antenna has a specific sector (tower band) within which the signals are active and get transmitted smoothly. However, if the distance increases and the source of the signal shift away from the active tower band or the working fringe, it becomes difficult for the antennas to catch the signal.
- In the case of urban areas, the possibility of congestion is high. Congestion refers to the phenomenon when the number of cell phones exceeds the usual limit that a cell tower can cater to. The number of subscribers/mobile phone users is high in urban areas, and the possibility of congestion is high. Thus, the signal gets weaker.
- In mountain areas, boulders, trees, and granite structures impede the propagating signals.
- Generally, any impediment that falls within the "line of transmission" obstructs the tower site performance.

Effects of Obstructions

- If the number of buildings (impediments) is high, the cell tower receives weak signals as the signals have to cross several interferences.
- Metals are the most powerful interference to the signals compared to the other materials. Therefore, any such obstruction directly affects the performance of the tower site.
- The distance between the cell tower and the source(s) of the signal should be calculated meticulously. If the distance exceeds the usual measurement (magnitude), the cell tower fails to receive signals from the fringe areas or receives very weak signals.

The following figure shows the effects of obstruction on signal propagation:

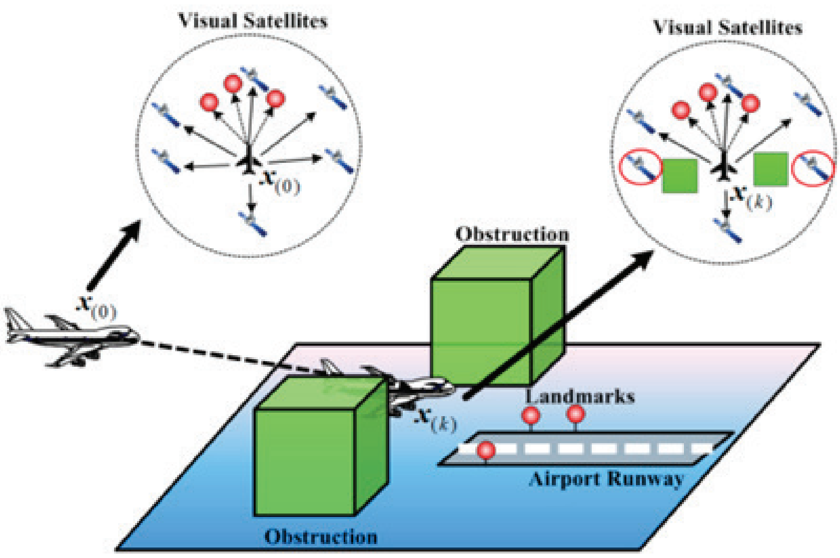

Fig. 5.3.1: Effects of Obstructions on signal propagation

Mitigating Techniques

- The distance between the two towers (serving and neighbouring cell towers) should be well measured so that they can cover a greater portion of the area with good signal coverage.
- Tower height should be augmented to increase the percentage of capture. The obstructions, such as tall buildings, should ideally be shorter in height than the adjacent cell tower.
- Use a good quality antenna as the antenna plays a pivotal role in catching and transmitting signals. Average quality antennas will not provide sufficient coverage.
- To avoid loss of signal strength owing to congestion, the RF diameter (coverage area) of the cell towers in the urban areas should be extended. To materialize this, the number of towers in congested areas should be increased.

Summary

- TEMS Pocket is a unique device-based testing solution which can be mounted to a drone to help you perform tests in hard-to-reach places.
- The application of technology, particularly wireless communication, is broadly used nowadays.
- Antennas can transmit and/or receive radio signals. Proper antenna setup and installation can drastically improve radio transmission distance and penetration capability.
- Direction angles of antennas are adjusted to change the coverage areas of cells.
- Downtilt angles of antennas are adjusted to change the coverage radius of cells.
- Network Operation Centres handle issues in a hierarchical manner so that if an issue is unresolved in a specific timeline, the next level is informed about pacing up to solve the problem.
- Any impediment that falls within the "line of transmission" obstructs the tower site performance.
- The distance between the cell tower and the source(s) of the signal should be calculated meticulously.

Exercise

MCQ

1. The antenna parameter adjusted for tower site optimisation is:
   a) Antenna azimuths
   b) Antenna tilts (Electrical/Mechanical)
   c) Antenna height and orientation
   d) All of the above

2. Downtilt angles of antennas are adjusted to change the ____________________of cells.
   a) Coverage radius
   b) Power
   c) Height
   d) None of the above

3. ________________________is tilting the antenna, through specific accessories on its bracket, without changing the phase of the input signal.
   a) Mechanical tilt
   b) Electrical tilt
   c) Automatic tilt
   d) None of the above

4. In telecommunication environments, NOC is responsible for:
   a) Investigating power failures
   b) Communication line alarms such as framing errors, bit errors, line coding errors and circuits down
   c) Prepare track details about the call flow
   d) All of the above

5. Which of the following is a troubleshooting step for 'no display' on a computer?
   a) Check the RAM as it might be a cause of no display
   b) Inspect the connector of the laptop responsible for the display
   c) Check the power supply of the laptop, i.e., the SMPS
   d) All of the above

Descriptive Question

1. What are the troubleshooting steps for laptopnot powering on?
2. What are tehtroubleshooting steps if the dat5a card gets hanged?
3. Explain various network optimisation techniques.
4. Whar antenna parameters are to be adjusted for tower site optimisation?
5. Differentiate between mechanical tilt and electrical tilt.

Notes

Scan the QR codes or click on the link to watch the related videos

https://www.youtube.com/watch?v=0Pk08wucjU8

Troubleshooting

https://www.youtube.com/watch?v=xcU7TCfRY7o

Tower Site Optimization Methods

Skill India
कौशल भारत - कुशल भारत

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

N·S·D·C
National
Skill Development
Corporation
Transforming the skill landscape

Telecom
Sector
Skill
Council

6. Communication and Interpersonal Skills

TEL/N9103

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. List organisational guidelines for dress code, time schedules, language and other soft skill aspects
2. Explain the importance of effective communication and interpersonal skills
3. Demonstrate appropriate communication skills and etiquette while interacting with others.
4. Discuss the common reasons for interpersonal conflicts and ways of managing them effectively
5. Discuss the need for implementing standards, guidelines and practices regarding gender sensitivity
6. Explain the work ethics, workplace etiquette, standards and guidelines to make communication inclusive for all genders and PwD.
7. List the health and safety requirements mandatory and recommended at the workplace for persons with disability
8. Describe the process of recruiting people with disability for a specific job
9. Demonstrate appropriate behaviour towards all genders and differently-abled people
10. Demonstrate appropriate behaviour towards all genders and differently-abled people
11. Illustrate the importance of team goals over individual goals

UNIT 6.1: Personal Hygiene and Dress Code

Unit Objectives

By the end of this unit, the participants will be able to:

1. List the organisation guidelines for personal hygiene and dress code

6.1.1 Personal Hygiene and Grooming

As per the World Health Organization (WHO), "Hygiene refers to conditions and practices that help to maintain health and prevent the spread of diseases." In other words, hygiene means ensuring that you do whatever is required to keep your surroundings clean, so that you reduce the chances of spreading germs and diseases.

For instance, think about the kitchen in your home. Good hygiene means ensuring that the kitchen is always spick and span, the food is put away, dishes are washed and dustbins are not overflowing with garbage. Doing all this will reduce the chances of attracting pests like rats or cockroaches, and prevent the growth of fungus and other bacteria, which could spread disease.

A Drive Test Engineer should have a general sense of hygiene and appreciation for cleanliness for the benefit of self and the customers. One should maintain basic personal hygiene at work, like clean-shaven, neatly tied hair for women, and neat and clean uniforms. Personal hygiene is essential to grooming standards and ensures the overall quality of services.

Dressing for success is an essential thing for a Drive Test Engineer. What you wear can affect how clients, your co-workers and managers treat you, your team, and your boss might perceive you.

Appearance

- Care should be taken to avoid any stains, broken buttons, or loose on the uniform.
- Shoes should be clean & polished at all times. Sandals/slippers/sports shoes and white socks should not be worn while on duty.
- Nails must be clean and cut most of the time
- Hair should be neatly combed before commencing duty, never in front of clients.
- Display ID cards when on duty so that it helps the customers identify the staff.
- A well-dressed appearance must be maintained in the workplace, even during off-duty hours.

Grooming Tips:

Here are a few grooming tips for the Drive Test Engineer that can impact their image and help convert customers.

- **Be hygienic -** The primary rule of proper grooming is staying hygienic. A person must always stay clean and hygienic while on duty, including keeping clean nails, hair, skin, teeth, and odours. Not keeping yourself hygienic can put a poor first impression in the minds of your customers and eventually impact your position. Bad hygiene can distract potential customers and even drive them away.
- **Dress according to the location -** A Drive Test Engineer should dress according to the region they are stationed in. Clothing like sarees and salwar suits for a female is also considered professional and helps the clients feel more familiar and at ease with the person. They should take advantage of this to ingrain more trust in their clients.

- **Dress neatly -** Dressing neatly is very important when it comes to putting the right first impression. A brand representative must wear washed and ironed clothes at all times, which impacts not just the salesperson's image but also the brand they're representing.
- **Wear the right attitude -** Wearing the right clothes is the first step. The Drive Test Engineer should al-ways be confident, which impacts hugely on the reliability.
- **Do not smoke -** Habits like smoking, chewing tobacco, or chewing gum put a negative image in custom-ers' minds. This is unacceptable for a brand representative and should be avoided at all costs.
- **Proper body posture -** Slouching while on duty and keeping hands in pockets or hips is not courteous to the customer and should be avoided. Maintain straight & upright posture while on duty.

6.1.2 Specific Uniform Guidelines

Drive Test Engineers are often exposed to public view; thus, the uniform plays a part in the visible brand identity. How employees dress can affect an organisation's morale, and many believe that a smart dress code can help improve performance. They generally encourage employees to wear smart casuals and business casuals. Some of the companies also provide uniforms with brand logos embedded in them.

A uniform can foster a sense of shared purpose amongst staff and give a organisation a unique identity, marking it out as a place where people are proud to work, and their service is valued. It also determines how the employees react to their surroundings, smartens up the business environment, and perhaps helps them feel more motivated to do their jobs to the best of their ability.

For men

- Smart casual wear includes a collared shirt or polo shirt with trousers such as chinos, dockers or cotton trousers for men
- Business standard for men is an outfit of a suit jacket and matching trousers, a formal collared shirt, with a tie and formal leather shoes, preferably brown or black
- The uniform prescribed should be clean and pressed
- Shoes should be clean and polished
- Hair must be short, clean & tidy
- One is expected to have a clean-shaven look. In the case of beards/moustaches, they must be trimmed, neat and tidy
- Nails should be trimmed neatly on a regular

For women

- For women, smart casual is a jumper, blouse, sweater or cardigan with a skirt, dress or trousers and shoes or boots. T-shirts and anything with a slogan is to be avoided.
- A blouse or suit with a smart skirt or tailored trousers and formal shoes is the female business outfit
- Women having long hair should tie their hair and not keep it loose. Too much oil should not be applied
- They should avoid bright-coloured nail paint and long nails as they will distract customers or damage the merchandise on display
- Minimum, non-flashy jewellery should be worn. Dangling earrings, noisy anklets and bangles must be avoided on duty
- Only light make-up to be applied (lipstick of light shades only)
- Junk jewellery, studs and bracelets should be avoided while on duty

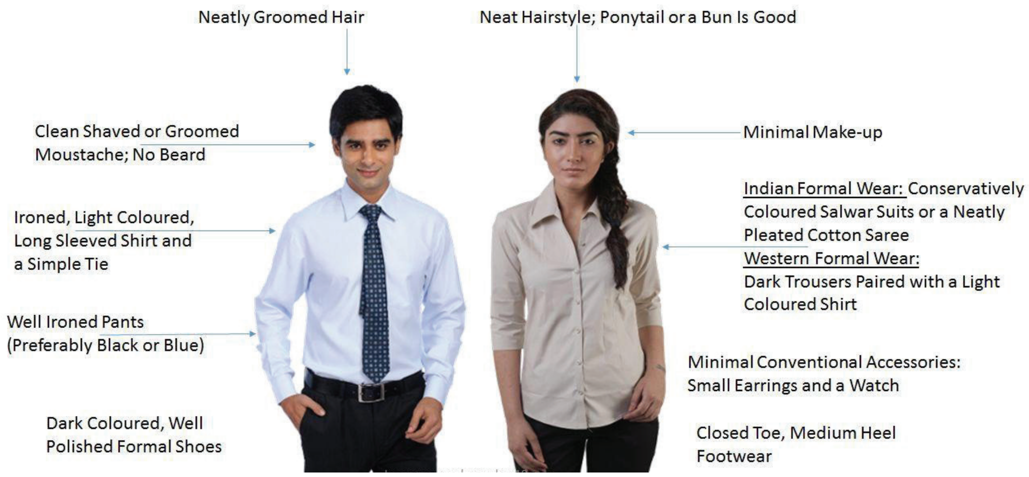

Fig: 6.1.2 A well-groomed female Customer Care Executive

UNIT 6.2: Importance of Effective Communication and Interpersonal skills

Unit Objectives

By the end of this unit, the participants will be able to:

1. Discuss about different methods of effective communication
2. Explain the importance of effective communication and interpersonal skills in the workplace
3. Identify the common reasons for interpersonal conflicts and ways to avoid them
4. Discuss ways to interact with supervisor regarding escalations, reporting and receiving feedback

6.2.1 What is Communication?

Communication is the process of sending and receiving information among people. It is imparting or exchanging information by speaking, writing, or using another medium. The purpose of communication is to convey your thoughts and opinions to others. Communication is said to be successful only when both the sender and the receiver perceive it similarly.

In your personal and professional life, you would be communicating with the following people

- Colleagues & Supervisor
- Customers & Clients
- Friends
- Parents & Relatives

6.2.2 Importance of Effective Communication

Communication is the act of giving, receiving, and sharing information -- in other words, talking or writing, and listening or reading. Good communicators listen carefully, speak or write clearly, and respect different opinions.

Every communication involves (at least) one sender, a message and a recipient. This may sound simple, but communication is actually a very complex subject.

The transmission of the message from sender to recipient can be affected by a huge range of things. These include our emotions, the cultural situation, the medium used to communicate, and even our location. The complexity is why good communication skills are considered so desirable by employers worldwide: accurate, effective and unambiguous communication is extremely hard.

It is very important to communicate effectively with team members and other stakeholders to create an atmosphere of accessibility. Stakeholders include employees, labour unions, suppliers, customers, business partners, investors and shareholders, the local community, government au-thorities, and regulators. However, they all vary in their interests, attitudes, and priorities, so proper communication and meetings are needed. Effective communication ensures that they re-ceive the relevant information to their needs and builds positive attitudes toward your company or project. Proper communication solves doubts and removes any negativity during the business. Good communication helps learn about each other's goals and objectives and is essential for meeting expectations. Maintaining proper telephone etiquette is also a part of professional communication

The proper and professional ways to communicate with team members and other stakeholders are:

- Give appropriate notice for a meeting
- Communicate through proper emails
- Frequent friendly informal communication with team members helps in strengthening relationships
- Pay attention to non-verbal communication through body language
- Be ready for feedback
- Show authority along with respect
- Give clear directions, not mere suggestions
- Always give a deadline for work given
- Give due importance to every team member's ideas
- Discuss problems along with solutions
- Use humour and fun to break the ice

A Drive Test Engineer interacts with clients & colleagues in three ways:

- Telephone and SMS
- Face to Face
- Documents

Therefore, they must develop their communication ability to ensure that the right message goes across.

Essentials of good communication

For effective communication, the Drive Test Engineer has to focus on four important things. They are:

- Understanding the client's & colleague's communication style
- Clarity in communication
- The Art of Listening and Art of Asking Questions

Clarity in communication

The Drive Test Engineer should clearly communicate with peers/seniors about tasks at the work-place. The communication of a Drive Test Engineer should be in a way that shows respect toward the listener and conveys a meaningful message.

- Knowing the information to be conveyed is an essential part of communication, and the person should know what needs to be conveyed in a very short and crisp manner.
- Limit yourself to the main points. If you say anything more than that, you confuse your listener. Anything less, and your message lacks substance.
- Focus on the individual's behaviour and avoid making slanderous remarks when speaking.

Your communication skills help you to build good relations with clients and co-workers. If you read that example fast, you might not find any errors. But on closer inspection, you will find one. There is one spelling error, and it is written felicitation instead of facilitation. Correct speaking also includes jargon-free language. The retail trainee associate should avoid jargon, especially when explaining the product's features, advantages and other benefits to the customers. There are chances that they may not be able to make sense of it. Here jargon refers to technical words like "The internet speed of this device is 200 Mbps." Or "The mileage of this bike is 75 km per litre", "This product is heat resistant", etc.

6.2.3 Interpersonal Conflicts

Interpersonal conflict is a normal, common occurrence in personal and professional relationships. If more than one person is involved, there will be different values, opinions, and thoughts, and these differences make people unique individuals.

Interpersonal conflict can be healthy; sometimes, it can result in a mutually beneficial solution and a closer, healthier relationship. On the other hand, when conflict escalates or is chronic and unresolved, this can be unhealthy and stressful, causing more overall conflict in a relationship.

The six types of interpersonal conflict are:

- Pseudo Conflict
- Fact Conflict
- Value Conflict
- Policy Conflict
- Ego Conflict
- Meta Conflict

Interpersonal Conflicts at Work

At work, conflict may arise when there is disagreement about policies, productivity, or expecta-tions. Co-workers may disagree about how best to complete a project, and management may disagree about how to discipline a staff member. These conflicts can arise when people don't feel they have the autonomy to make decisions or disagree about how things are done.

Conflicts at work can be difficult because of power dynamics, work culture, or a stressful envi-ronment. When possible, it's a good idea to ensure everyone has a voice. Try a brainstorming session or give honest feedback. Support positive morale. Employees are generally more produc-tive and happier when they feel heard, valued, and understand the mission.

Ways to Avoid Interpersonal Conflicts at Work

For your conflict to be resolved, your communication has to be productive. Things like insults or going around in circles will only dig you into a deeper hole.

Here's a list of things to avoid when trying to resolve interpersonal conflicts:

- Serial arguments, going around and around about the same topics
- Placing blame on others
- Cross-complaints, or responding to an issue with a different complaint
- Not fighting fair
- Continuing to fight when things get heated, when it's often better to take a break
- "Kitchen-sink" arguments, where every problem in the world is brought up
- Insults or name-calling
- Mind Reading

6.2.4 Communicating with Supervisors

Maintaining etiquette, using polite language, and demonstrating responsible and disciplined behaviours to supervisors are important. Several basic norms and etiquette need to be maintained at the workplace, such as:

- Use friendly body language while greeting colleagues
- Greet colleagues and supervisors with a smile
- Practice patient listening
- Display supportive behaviour in a team
- Prohibit misbehaving at the workplace since this can harm the work culture
- Listen actively in a two-way communication

Effective communication with your supervisor is key to your eventual success in the workplace. Therefore, it is crucial that you feel comfortable and prepared to approach your supervisor promptly to discuss concerns, request assistance, or report work progress.

For example, It is essential to communicate the maintenance and repair schedule proactively to the

superior and receive feedback on work standards. The documentation for the completed work schedule should be maintained and handed over to the supervisor.

Escalating Issues to Supervisor

Whether an issue arises among team members or with customers, sometimes the severity of the circumstance requires an escalation to management. Understanding how to approach an escala-tion can help you better find a solution when conflicts arise. We explore what it means to esca-late an issue in the workplace and provide tips for how to do so successfully.

Escalating an issue in the workplace is the process of bypassing those involved by contacting upper/ senior management. It involves raising awareness of the context to the right people to resolve a challenging situation. Typically, escalation occurs when there is an issue that the current staff working on the problem can't fix and requires assistance from those with more authority and re-sources.

When to escalate an issue?

Deciding when to escalate an issue depends on the amount of risk it can bring to the company. Because escalating a problem can lead to difficult meetings and cause disruptions in work, you should reserve them for issues that genuinely require escalation. You can often avoid escalating an issue by first solving the problem with the individual; however, some cases require support from those with higher authority. Consider escalating an issue at work when:

- You have already tried other strategies, but they did not work.
- Resolving may incur additional costs to the company or the customer while rectifying the problem.
- Because of the non-availability of particular parts, the repair work is taking longer than usual.
- The engineer broke another part while repairing a part. So escalation is required to get the approval to replace the broken part of the company.

6.2.5 Barriers to Effective Communication

Irrespective of the type of communication: verbal, non-verbal, written, listening or visual, if we don't communicate effectively, we put ourselves and others at risk. Besides physical and technical barriers, there are multiple barriers to effective communication every everyone in the workplace should try to eliminate.

- Dissatisfaction or disinterest with one's job
- Stress and out-of-control emotion
- Inability to listen to others
- Lack of focus
- Lack of transparency & trust
- Communication styles (if they differ)
- Inconsistent body language
- Cultural differences & language
- Conflicts in the workplace

UNIT 6.3: Gender and PwD Sensitisation

Unit Objectives

By the end of this unit, the participants will be able to:

1. Illustrate the guidelines for gender-neutral behaviour in communication with clients and col-leagues
2. Discuss about PwD sensitisation at the workplace
3. List the rights, duties and benefits available at the workplace for persons with disability

6.3.1 Non Discrimination Policies

In any business, be it a small company to a big corporate, the workforce is a mix of both genders. The ratio of men vs women varies from 70:30 or 60:40. Studies show that business teams with an equal gender mix perform significantly better than male-dominated teams regarding sales and profits. No two women or men are alike, yet at the same time, some work-related traits are gen-der specific. Both men and women approach their work differently and deal with many hurdles that come their way.

Since they all share the same workspace, every organisation has devised a policy as to how they treat the opposite gender at the workplace and what are the implications of any abuses

In a gender-neutral work environment, employees are encouraged to be empathetic and re-sponsible towards everyone's needs and be open to diverse personalities and opinions, thus cre-ating a truly inclusive work culture.

Any sort of discrimination is bad, and it can be worse if practised against colleagues and clients. All clients should be treated equally and should not feel differentiated based on race, sex, gender identification, sexual orientation, place of origin, native language, religion, age, disability, marital status, or other parameters. In India, there are various legislations to prevent discrimination. They are:

- Article 14 of the Constitution- Equality before law. -The State shall not deny to any person equali-ty before the law or the equal protection of the laws within the territory of India.
- Article 15 of the Constitution- prohibits discrimination by the state against any citizen on grounds 'only' of caste, religion, sex, race, and place of birth. Fundamental rights are provided to every cit-izen of the country without any discrimination.
- Article 25-28 of the Constitution of India- Freedom of religion in India
- The Scheduled Castes and Tribes (Prevention of Atrocities) Act, 1989
- Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013;
- Section 9(1) says that any aggrieved woman can make a complaint of sexual harassment at the workplace to the internal committee, in written form, within 90 days from the date of the inci-dent, and in case of a series of incidents, within 3 months from the date of the last incident.
- The Persons with Disabilities (Equal opportunities, protection of rights and full participation) Act, 1995
- The Transgender Persons (Protection of Rights) Act, 2019).

Some of the points to remember while interacting with female colleagues:

- Treat them with respect
- Support them in case they approach you
- Value their opinion and suggestions
- Involve and include the opposite gender in all the discussions

6.3.2 Guidelines for Gender Neutral Behavior at Workplace

Principles of gender-sensitive communications

- **Ensure that women and men are represented -** It is important to ensure that quotes from both men and women are included in press releases, stories and other communications. Additionally, presenting female voices in traditionally male roles and vice versa contributes to deconstructing stereotypes and gender norms. Such messages, including visuals and written messages, can positively impact people's attitudes over time. When preparing press releases, stories and other materials, it is important to plan and clarify how women's and men's voices can be captured.
- **Challenge gender stereotypes -** Our use of language often reinforce gender stereotypes, and assumptions about women and men are often formed through such gender stereotypes. It is important to avoid using these, as gender stereotypes limit and trivialise both women and men, presenting inaccurate images.

  It is important not to represent certain vocations or roles only appropriate for or held by women and men. For example, doctors are men, and nurses are women. It is also critical not to imply, for example, that women and girls are timid in comparison to men and boys or that females are passive and males are active. Similarly, one should avoid 3 using phrases that stereotype women's or men's behaviour or thought processes. For example, gender stereotypes are deployed when describing men as aggressive or violent and when describing women as emotional, shrill, or passive.
- **Avoid exclusionary forms -** Exclusionary forms of language indicate the use of "he"/"his" when referring to both a female and a male, which excludes females. One can use "he" and "she" to be inclusive or use the plural 'they' to avoid using any gendered pronouns. When using gendered pronouns, it is important not to confuse your audience by using the in one paragraph and he in the next. In these situations, it is good practice to stick to one pronoun, use a plural, or eliminate the use of pronouns by rewording the sentence. In addition, when used sparingly, using him or her in a sentence can be a good way to include both sexes.
- **Use equal forms of address -** Addressing women by their marital status is an old practice dating back to the 1700s. Women were often called by their husbands' full names, for example: 'Mrs. John Smith.' Nowadays, however, this practice is no longer appropriate. While the address 'Mrs.' implies that the woman is married, 'Ms.' emerged in the 1940s as an alternative to 'Mrs.'. Today, the 'Ms.' form is universally accepted and a good practice to adopt.

  In the same way, women are often referred to as someone's partner instead of an indi-vidual in their own right, which creates an imbalance in who is deemed important in pub-lic life. It is good practice to avoid referring to women as somebody's wife, widow or mother unless necessary.

  However, it is important to be mindful and respectful of how individual women prefer to be addressed. For example, if a woman refers to herself as 'Mrs.', or adopts her hus-band's name in correspondence, it is important to respect this choice and subsequently refer to her with the name of her choosing.
- **Create a gender balance -** In written and oral communications, it is important to be mindful of the gender implications of generic terms. Generics are nouns and pronouns intended to be used for both women and men. For example, the terms' fatherland' or 'mankind' describe concepts that encompass men and women, but both terms are male-dominated. Male-specific generics tend to call up primarily male images for readers and listeners. It is best to avoid such generics to cre-ate a more gender-inclusive language.

  Similarly, word order can often assume that one sex is superior to the other or that the latter sex is an afterthought. For example, the phrases men and women or ladies and gentlemen may give this impression. Instead, it is better to address groups of people with generic terms. For example, addressing a group as colleagues or members of the delegation avoids using any gender bias.

- **Promote gender equity through titles, labels, and names -** Titles for people and occupations of-ten reflect inequitable assumptions about males and females; gender-sensitive language pro-motes more inclusive and equitable representations for females and males. For example, instead of using actress or stewardess, for women professionals, it is better to use the generic term (ac-tor or flight attendant) to avoid promoting gender inequality.

Use of Non-Gendered Statements in Communication at the Workplace

Gender-Inclusive Language

Gender-inclusive (or gender-neutral) language is the language that does not discriminate against gender identities and/or groups.

Language is essential to building a company where everybody feels welcomed and included- even before people join the team. Not asking about gender on application forms and using 'they' when the gender of a job applicant is unknown are gender-inclusive practices, as is having style guides in place that highlight the importance of gender-neutral language.

'Guys' is one of the most common ways of addressing groups of people in the English language; we use it often in everyday conversation without giving much thought to its impact. But 'guys' can be considered gender-specific, making it confusing or unappreciated when referring to a group that includes women.

6.3.3 PwD Sensitisation at Workplace

Awareness of persons with disabilities is key for professional and everyday interaction. Training classes and other materials are available to provide the workplace with the necessary tools to in-teract with co-workers and clients.

The following are some of the things to consider when interacting with individuals with disabili-ties:

- Always ask before you help
- People desire to be independent and treated with respect
- Be respectful about physical contact
- People depend on their arms for balance and consider equipment part of their personal space
- Think before you speak
- Speak directly to the person
- Don't make assumptions
- People are the best judge of what they can or cannot do
- Accommodation is not a complaint

Communication with Disabled Person

A disability is any condition that makes it more difficult for a person to do specific tasks or interact with the people around them (socially or materially). These conditions, or defects, may be cogni-tive, developmental, intellectual, mental, physical, sensory, or a combination of multiple conditions. Defects may be present from birth or acquired during a person's lifetime. Often, disabled people are excluded from full participation in any activity."

But things are changing; every organisation has allotted some percentage of employees from this section of society. They are also allowed to exhibit their skills in a few jobs which they can perform without putting their life at risk

General tips for communication with disabled people:

- Speak to them as you would speak to anyone else in a soft and low tone.
- Respect the person first, not their disability. For example, use the term a person with a disability rather than a disabled person.
- Do not use phrases such as 'suffers from' and 'crippled' rather, the phrase should be 'people who use a wheelchair rather than wheelchair-bound.
- Don't drag or push a person's wheelchair, and don't move their crutches or walking stick without permission. It has to be in their personal space.
- When talking to a person in a wheelchair, try to sit so you can reach their eye level, as this would not strain them much to lift their head and talk.

Communicating with People with a Hearing Impairment

Keep these points in mind while interacting with people with a hearing problem:

- Draw the person's attention before you speak. Give a gentle tap on their shoulder, a wave of some other visual signal to the person's attention
- Stand in front of the person and maintain eye contact
- Don't cover the mouth while talking. They can figure out what is being said by just looking at the lip movement
- Speak at an average pace; Do not speak too fast or slow
- Choose the words wisely
- Use short sentence
- Be gentle while speaking; don't raise the tone

Respect People with Disability

Learn the proper way to act and speak around someone with a disability.

- Do not use offensive or derogatory words like 'handicapped', 'crippled', retarded etc.
- Do not criticise or blame them. Do not shout at them or use abusive language
- Talk slowly with a low tone. Pause while talking
- Avoid excessive whispering, joking and laughing unnecessarily
- Assuming things about them or their situation.
- Please do not make jokes about their condition or be sarcastic
- Do not look down upon them because of their disability
- Appreciate them for their efforts and work, and motivate them to perform better

6.3.4 Safety for People with Disability

Disabilities affect employees and can pose various mental or physical challenges. In many situations, a disability may impact the time it takes for an employee to complete a task or get from one part of a facility to another. Some disabilities may be known, while others remain unknown to an employer.

Health and safety legislation should not prevent disabled people from finding or staying employed, so it should not be used as an excuse to justify discrimination against them. Disabled people and those with health conditions, including mental health conditions, should be allowed to both get into and stay at work.

It is the responsibility of persons with disabilities to inform their employers about their needs; cooperate in obtaining necessary information, including medical or other expert opinions; participate in discussions about solutions, and work with the employer and union on an ongoing basis to manage the accommodation process.

Employers are required to accept requests for accommodation in good faith; request only information that is needed to make the accommodation; obtain expert advice or opinion where necessary; take an active role in ensuring that possible solutions are examined; maintain the confidentiality of persons with disabilities; deal with accommodation requests in a timely way, and bear the cost of any required medical information or documentation.

Everyone involved must treat human rights issues arising in the workplace thoughtfully and respectfully.

Responsibilities of an employer towards disabled people

The employer is responsible for their employees' health, safety and welfare, whether they have a disability or not. Disability is not always obvious, so one might not realise a worker is disabled, or they might choose not to tell you, particularly if their disability has no impact on their ability to do their job.

Workers do not have to tell anybody unless they have a disability that could foreseeably affect the safety of themselves or anyone else connected to their work. If they do not reveal and there areno obvious indicators of any disability, then the organisation are not under any obligation to make workplace adjustments.

Periodically, please consult with the employees (whether directly or through their representatives) on issues relating to health and safety. These discussions reflect good safety practices because employees have a day-to-day understanding of the job, so they are likely to have good ideas on keeping themselves and others safe.

Workplace adaptations for people with disability

The workplace should be easily accessible for these people with special needs. One primary compliance concern deals with accessibility. For example, if workplaces have been adjusted or created with more accessible entrances and exits to their facilities, allowing more independence for persons in wheelchairs would be a great idea. Other subtle changes may include the width of bathroom stalls, handrails inside the stalls and long ramps instead of stairs. The path of travel that employees take should never be obstructed; there should be no barriers to prevent someone from getting to safety in an emergency.

Workstations can easily be adapted to follow this universal design. Many companies now use slide-out keyboard trays and monitors on swinging arms to allow employees to adjust to their needs. Desks can accommodate wheelchairs in place of regular chairs, and general workspaces can be lowered to allow easier access. The main goal is to remove all barriers and allow everyone to concentrate more on completing their tasks.

The biggest challenge with universal design is accommodating the multitude of challenges that different disabilities present. Not all disabilities are the same, and not all will present the same challenges for employees. Some employees may have issues with their right hand, while others have problems with their left. For some, it may involve not being able to stand or sit. Some may need low lighting, while others need bright lighting. Designing a facility to accommodate all is always going to be a challenge. Complying with government guidelines can be more difficult for employees with disabilities.

This difficulty lies with ensuring that employees are aware of all hazards in the workplace. Multiple disabilities will create multiple reasons that may keep employees from recognised hazards. Employees with impaired vision, for example, must have other means of identifying threats. This may be remedied with audible alarms or touch-activated devices that warn employees not to go in an area. Other employees may have difficulties reading and may benefit from shapes or colours to identify hazardous areas further. For workers who lack hearing ability, employers can use signs to demonstrate hazards or flashing strobes to identify when employees need to evacuate an area and head to safety.

Every organisation has to make a few adaptations to make it a better workplace, even for people with disabilities. It should provide an environment where they feel safe and can carry out their work rather than worrying about their safety.

6.3.5 Recruiting Candidates with Disabilities

It's very often understood how employers who feel included in their workplace are more likely to show higher efficiency, passion and allegiance to the company than the others. Thereby, recruit-ers need to understand that it's not just about recruiting people with disabilities but also about diversity management.

- Make sure the company has the right infrastructure
- Partner with community-based organisations or NGOs
- Modify the application process
- Interview people with disabilities impartially

UNIT 6.4: Work Ethics and Team Goals

Unit Objectives

By the end of this unit, the participants will be able to:

1. Demonstrate ideal workplace ethics while interacting with colleagues
2. Follow the organisation's policy for working with team members
3. Illustrate the importance of team goals over individual goals

6.4.1 Work Ethics

Being ethical in the workplace means displaying values like honesty, integrity and respect in all yourdecisions and communications. It means not displaying negative qualities like lying, cheating and stealing.

Workplace ethics play a big role in a company's profitability, and it is as crucial to an enterprise as high morale and teamwork. This is why most companies lay down specific workplace ethic guide-lines that their employees must compulsorily follow. These guidelines are typically outlined in a company's employee handbook.

Elements of a strong work ethics

Employees must display strong work ethics and hire only those who believe in and show the same ethical behaviour in the workplace. Some elements of a strong work ethic are:

- **Professionalism:** This involves everything from how you present yourself in a corporate setting to how you treat others in the workplace.
- **Respectfulness:** This means remaining poised and diplomatic regardless of how stressful or volatile a situation is.
- **Dependability:** This means always keeping your word, whether arriving on time for a meeting or delivering work on time.
- **Dedication:** This means refusing to quit until the designated work is done and completing the work at the highest possible level of excellence.
- **Determination** means embracing obstacles as challenges rather than letting them stop you and pushing ahead with purpose and resilience to get the desired results.
- **Accountability:** This means taking responsibility for your actions and the consequences of your ac-tions and not making excuses for your mistakes.
- **Humility:** This means acknowledging everyone's efforts and hard work and sharing the credit for accomplishments.

How to adopt a good work ethic

As an employee, it is essential that you clearly define the kind of behaviour that you expect from every team member in the workplace. It would help if you made it clear that you expect em-ployees to display positive work ethics like:

- **Honesty:** All work assigned to a person should be done with complete honesty, without deceit or lies.
- **Good attitude:** All team members should be optimistic, energetic, and positive.

- **Reliability:** Employees should show up where they are supposed to be when they are supposed to be.
- **Good work habits:** Employees should always be well groomed, never use inappropriate language, conduct themselves professionally, etc.
- **Initiative:** Doing the bare minimum is not enough. Every team member needs to be proactive and show initiative.
- **Trustworthiness:** Trust is non-negotiable. If an employee cannot be trusted, it's time to let that employee go.
- **Respect:** Employees must respect the company, the law, their work, their colleagues and themselves.
- **Integrity:** Every team member should be completely ethical and display above-board behaviour.
- **Efficiency:** Efficient employees help a company grow, while inefficient employees result in a waste of time and resources.

6.4.2 Team Work

Teamwork occurs when the people in a workplace combine their skills to pursue a common goal. Effective teams are individuals who work together to achieve this common goal. A great team holds itself accountable for the result.

Importance of Teamwork

Building an effective team is critical to the success of a project. An employee must ensure that the team makes certain crucial qualities, traits and characteristics. An effective team has:

- **Unity of purpose:** All team members should clearly understand and be equally committed to the team's purpose, vision and goals.
- **Practical communication skills:** Team members should be able to express their concerns, ask questions, and use diagrams and charts to convey complex information.
- **Ability to collaborate:** Every member should feel entitled to provide regular feedback on new ideas.
- **Initiative:** The team should consist of proactive individuals, and the members should be enthusiastic about developing new ideas, improving existing ideas, and conducting their research.
- **Visionary members:** The team should have the ability to anticipate problems and act on these potential problems before they turn into real issues.
- **Excellent adaptability skills:** The team must believe that change is a positive force. Change should be seen as the chance to improve and try new things.
- **Excellent organisational skills:** The team should have the ability to develop standard work processes, balance responsibilities, properly plan projects, and set in place methods to measure progress and ROI.

6.4.3 Individual Goals vs Team Goals

A Goal is a term commonly used throughout many fields. Depending on the context, what makes up a goal can vary and be quite different. Goals can have various purposes; some goals will be fo-cused on the individual, and others can be specific to the team.

Individual Goals are specific to the individual's roles and responsibilities. Personal development goals are objectives to improve your character, skills and capabilities. Setting these goals involves assessing yourself and identifying the areas in which you can improve to maximise your potential. To start personal development, you should create a plan with actionable steps.

Team Goals are related to those pivotal strategies to the team's success. Goals in these situations might be related to a particular tactical philosophy. Team goals provide a clear direction and plan of action for your team. Team goals create opportunities to build trust and collaboration. Team goals contribute to the professional growth and development of new skills among team members. Team goals provide a structure for measuring individual and group-level progress.

Some of the examples of team goals:

- Increase customer satisfaction ratings
- Increase customer retention ratings
- Onboard more customers
- Reduce customer contact volume
- Increase social media engagement
- Decrease client response time
- Decrease resolution time
- Reduce the project turnaround time
- Increase client satisfaction

SMART goals

The SMART acronym is short for:

- Specific: The exact thing you and your team want to achieve
- Measurable: The numerical constraints (how much effort will it take, how long will it take, how much will it cost, how will you monitor progress, etc.)
- Achievable: Can this goal be accomplished?
- Relevant: How will this goal benefit the team and the business?
- Time-based: When should the goal be accomplished?

Summary

- Hygiene refers to conditions and practices that help to maintain health and prevent the spread of diseases
- A Drive Test Engineer should have a general sense of hygiene and appreciation for cleanliness for the benefit of self and the clients
- A well-dressed appearance must be maintained in the workplace, even during off-duty hours.
- Communication is the process of sending and receiving information among people. It is imparting or exchanging information by speaking, writing, or using another medium.
- Every communication involves (at least) one sender, a message and a recipient. This may sound simple, but communication is actually a very complex subject.
- Interpersonal conflict is a normal, common occurrence in personal and professional relationships.
- Conflicts at work can be difficult because of power dynamics, work culture, or a stressful environment.
- In a gender-neutral work environment, employees are encouraged to be empathetic and responsible towards everyone's needs and be open to diverse personalities and opinions, thus creating a truly inclusive work culture.
- Awareness of persons with disabilities is key for professional and everyday interaction.
- As an employee, it is essential that you clearly define the kind of behaviour that you expect from every team member in the workplace.
- Individual Goals are specific to the individual's roles and responsibilities. Team Goals are related to those pivotal strategies to the team's success.

Exercise

Multiple-choice Questions

1. Be ______ in speaking to your peers at the office.
   a. Rude b. Polite
   c. Aggressive d. None of the above

2. _______ are movements of hands and body to help explain or emphasize the verbal message.
   a. Gestures b. Body posture
   c. Head nods d. None of the above

3. __________ involves everything from how you present yourself in a corporate setting to how you treat others in the workplace.
   a. Professionalism b. Respectfulness
   c. Dependability d. Accountability

4. _________ means taking responsibility for your actions and the consequences of your actions and not making excuses for your mistakes.
   a. Professionalism b. Respectfulness
   c. Dependability d. Accountability

5. Your ________skills help you to build good relations with clients and co-workers.
   a. Communication b. Technical
   c. Hard d. None of the above

Answer the following:

1. What is communication?
2. How to communicate with people with hearing impairment?
3. How to avoid interpersonal conflicts at workplace?
4. Explain the importance of gender sensitisation.
5. Differentiate between team goals and individual goals.

Notes

7. Manage Work, Resources and Safety at Workplace

Telecom Sector Skill Council

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Key Learning Outcomes

By the end of this module, the participants will be able to:

1. State the importance of keeping the workplace clean, safe and tidy
2. List the types of hazards and the emergency procedures related to them
3. Discuss the importance of sanitising and disinfecting one's work area regularly.
4. Describe the significance of conforming to basic hygiene practices such as washing hands, using al-cohol-based hand sanitisers
5. Employ ways for efficient utilisation of material and water.
6. Use energy-efficient electrical appliances and devices to ensure energy conservation.
7. Illustrate some ways to cope with stress, anxiety etc., with the team members.
8. Evaluate various methods of waste management and disposal.
9. Define the concepts of recyclable, nonrecyclable and hazardous waste

UNIT 7.1: Workplace Hygiene and Safety

Unit Objectives

By the end of this unit, the participants will be able to:

1. Discuss about workplace safety
2. Explain workplace hazards and how to treat workplace hazards
3. Elaborate the process of reporting hazards
4. Demonstrate workplace hygiene
5. Explain ways to handle poor hygiene at the workplace

7.1.1 Organisational Hazards

Safety is the responsibility of all employees, whether at the job site or in a factory. The employer has the prime liability for safety, but every employee should be knowledgeable about safety and be able to work safely without any safety violations. As a member of the plant team (inside a phys-ical office) or the site team (in a job site or a factory), you are responsible for:

- Your safety
- Reporting any unsafe circumstances or practices to the safety supervisor/administrator
- Following all specific safety requirements as outlined in the specification and by the safety engi-neer or supervisor
- Knowing the location of first aid stations
- Knowing the nearest and emergency telephone numbers like ambulance, fire department, safety engineers etc.

The most common workplace hazards are:

Slips, Trips and Falls: Universal slip, trip and fall culprits include unattended spills, wet floors, ex-posed cords, unstable work surfaces, uneven floors, loose rugs and cluttered areas.

Clean up all spills immediately, and post signs identifying hazards in areas that are being cleaned or that have recently been cleaned and in areas prone to water accumulation and wet surfaces. Of-fice walkways should be kept clear, as boxes and other clutter can create a trip hazard. Electrical and telephone cords should also be adequately secured and not stretched across aisles or walk-ways, and carpets should not be frayed or buckled.

Ergonomic Injuries: Drive Test Engineers spend many hours a day seated inside a car, working on a computer, resulting in ergonomic strains and other injuries related to posture and repetitive movement. These types of hazards can be challenging to detect. It is important to rest and do proper stretching to maintain the blood flow.

For desk workers, various adjustable chairs, desks, keyboards, etc., should be offered to accom-modate the broadest range of work styles. Employees should be told how to set up and operate adjustable equipment for the best workstation fit.

Eye Strain: Spending a large portion of your workday at the computer can cause eyestrain. Eyes may become dry and irritated, and workers may have trouble focusing.

You can cut down on excessive glare by closing blinds on windows and dimming the overhead lights. Correctly positioning monitors slightly below eye level, minimising screen glare and increas-ing computer font size can help alleviate eyestrain.

Fire Safety: If employees use space heaters, verify that the appliances are approved for commer-cial use and have a switch that automatically shuts them off if they tip over. Space heaters should not be placed near combustible materials like paper.

Objects should never be placed closer than 18 inches below fire-sprinkler heads to allow a full range of coverage. Emergency-exit routes should never be blocked or locked. It's also critical that employees be trained on what to do if a fire erupts

Indoor Air Quality: The prevalence of poor indoor air quality has contributed to a rise in occupa-tional asthma and other respiratory disorders, chemical sensitivity and allergies. Preventing the ac-cumulation of dust, pollen, dirt and other buildups on all surfaces, especially carpeting, will also re-duce respiratory irritants, infections and illnesses.

Cleanliness and orderliness, too, may prevent the spread of illnesses and diseases in the work-place. Restrooms, break rooms, lunch areas, and refrigerators should be regularly sanitised, and workers should be told to throw out food before it spoils.

Every organisation must ensure that the workplace follows the highest possible safety protocol. When setting up a business, some tips to remember:

- Use ergonomically designed furniture and equipment to avoid stooping and twisting
- Provide mechanical aids to avoid lifting or carrying heavy objects
- Have protective equipment on hand for hazardous jobs
- Ensure the presence of emergency exits and that they are easily accessible
- Set down health codes and ensure they are implemented
- Follow the practice of regular safety inspections in and around the workplace
- Get expert advice on workplace safety and follow it
- Get a routine inspection of electrical wiring and also the electrical switches and gadgets
- Install fire extinguishers and fire alarms

A hazard is a source of potential damage or adverse health effects on something or someone. It has the potential for harm or a negative impact (for example, people as health effects, organisa-tions as property or equipment losses, or the environment).

Mechanical safety issues can occur related to the operation of any machine in the workplace. Noise and visibility issues can compromise an employee's hearing and sight. Falls resulting from poor housekeeping or negligence can cause severe injury and death; procedures should be in place to prevent them. Ice, snow and rain can create hazards; employees need to be trained to operate equipment safely when weather conditions are bad.

7.1.2 Workplace Safety Policies

Each business should have a safety policy created either by management or in a joint effort be-tween management and staff. Every employee has a role in carrying out the safety policies. A safe-ty handbook should be created to identify safety issues and spell out the consequences of not fol-lowing the appropriate safety procedures.

Importance of Safety Training: Training is necessary to know the importance of safety and how to practice safety in the workplace. Depending on the type of equipment used, training may be re-quired.

Training can come from outside experts hired to teach classes or employees specially trained to perform safety instruction.

Workplace Safety Equipment: Appropriate personal protective equipment (PPE) must be available to anyone who comes in contact with a potential work safety hazard. This can include hard hats, protective eyewear, earplugs, shoes, gloves and clothing. Even an office worker who delivers a message to a work area near a potential safety hazard must put on the appropriate PPE.

Benefits of Workplace Safety: Safety in the workplace results in fewer accidents, fewer costs for worker's compensation, less downtime for employees, and less retraining time for workers other-wise needed to replace an injured worker. Avoiding damage to equipment will result in fewer re-pair costs. Worker performance is improved when workers know how to prevent injuries and have confidence in management's active role in protecting their safety.

Non-Negotiable Employee Safety Habits

Every employee must follow all safety protocols put in place by the organisation. All employees must make it a habit to:

- Immediately report unsafe conditions to the supervisor
- Recognise and report safety hazards that could lead to slips, trips and falls
- Report all injuries and accidents to the supervisor
- Wear the correct protective equipment when required
- Learn how to use equipment provided for safety purposes correctly
- Be aware of and avoid actions that could endanger other people
- Always be alert
- Educate the employees about the first/emergency exits on the floor and also where the fire extinguishers are kept.

7.1.3 Reporting Hazards

Taking action (responding)

- Protecting the health and safety of protecting the health and safety of others
- Providing first aid to injured persons on site
- Summoning emergency medical team and rushing injured persons to the hospital
- Taking essential action to make the site safe or to prevent a further incident
- Isolating the emergency site to prevent further accidents
- Repair and restoration work may be started after an Inspector confirms that the site runs no further risks of accidents

Reporting hazardous events

Every organization, from every industry, has a standard reporting protocol, comprising the details of people in the reporting hierarchy as well as the guidelines to be followed to report emergencies. However, the structure of this reporting hierarchy varies between organizations, but the basic purpose behind the reporting procedure remains same.

The general highlights of the Organizational Reporting Protocol, commonly known as the 6Cs, are:

- Communicate First
  - The first source of information during emergency is the preferred source.
  - Crises situations are time-bound and hence it is important to communicate promptly.

- Communicate Rightly
    - o Distortion of information due to panic must be avoided.
    - o Proper, accurate information must be provided to concerned authorities and this can save lives.
- Communicate Credibly
    - o Integrity and truthfulness must never be forgotten during emergencies.
- Communicate empathetically
    - o One must wear the shoes of the victims while communicating emergencies.
- Communicate to instigate appropriate action
    - o Communicating to the right authorities help in taking the necessary action.
- Communicate to promote respect
    - o Communicating with the victims with respect help in earning their trust and thus eases the disaster management process.

Hazards and potential risks / threats can be identified and then reported to supervisors or other authorized persons in the following ways:

While identifying and reporting a hazard / potential threat / potential risk, one must describe the following:

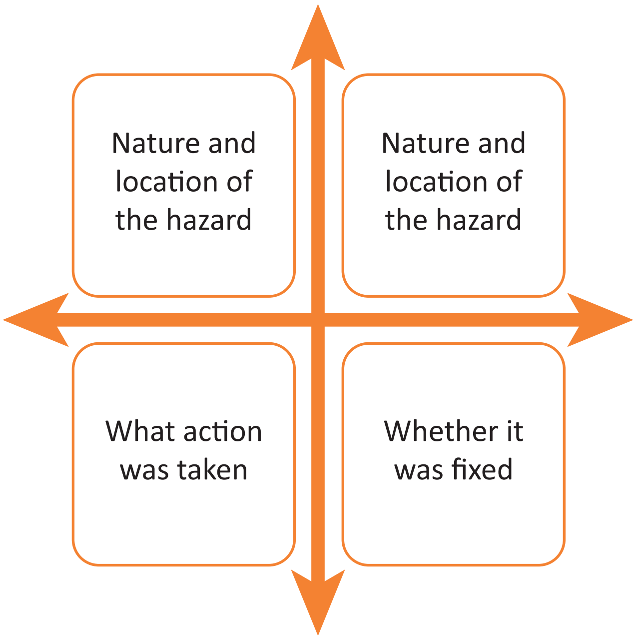


Fig. 8.4.1: Describing hazard matrix

Part A: To be completed by the Worker Details Required:

- Name of Worker
- Designation
- Date of filling up the form
- Time of incident / accident
- Supervisor / Manager Name

- Work Location / Address
- Description of the hazard / what happened (Includes area, task, equipment, tools and people involved)
- Possible solutions to prevent recurrence (Suggestions)

Part B: To be completed by the Supervisor / Manager Details Required:

- Results of Investigation (Comment on if the hazard is severe enough to cause an injury and mention the causes of the incident / accident)

Part C: To be completed by the Supervisor / Manager Details Required:

- Actions taken / Measures adopted (Identify and devise actions to prevent further injury, illness and casualty)

Action	Responsibility	Completion Date

Any job role and any occupation in this world have some hazards, in varying severity, associated with it. These are called Occupational Hazards. Occupational Hazard can be defined as "a risk accepted as a consequence of a particular occupation". According to the Collins English Dictionary, it is defined as "something unpleasant that one may suffer or experience as a result of doing his or her job". Occupational Hazards are caused by the following:

Hazard Report Form	
Name:	Date:
Location:	
Tool/Equipment:	
Description of the hazard:	
Suggested correction action:	
Signature:	
Supercisor's remarks:	
Corrective Action taken:	
Sinature of Supervisor:	Date:

Fig 8.4.2: Sample form of reporting hazards

7.1.4 Workplace Hygiene

Workplace hygiene refers to the standards of cleanliness that employers are expected to meet in ensuring that they provide a healthy working environment in which their staff can work, as well as clean and safe premises for members of the public to visit.

The work area should be in a clean and tidy condition. Cleaning and maintenance play a vital role in upholding the office's prestige. Neat and clean public areas clearly indicate the office's standard. It creates a lasting impression in the guests' minds, resulting in a positive brand image. Entrances cre-ate the first impressions, so it is crucial to keep them clean. Floors and lobby areas should be mopped periodically to maintain hygiene. Indoor plants add to the property's aesthetics, so water-ing indoor plants and floor dusting form an integral part of this job. A damp dusting of furniture en-sures the longevity of polish. Every nook and corner of the public area should be cleaned to elimi-nate any infestation.

To ensure proper ventilation and a fresh supply of air, several steps could be taken, such as:

- **Natural ventilation:** keeping the doors and windows open for sufficient hours may help reduce the saturation of carbon monoxide and vapours within the room and draw insufficient sunlight.
- **Spot ventilation:** Maintaining extra ventilation in commercial kitchens or near equipment such as photocopiers and printers can reduce the volume of carbon dioxide and other gases in an office.
- **Air conditioning:** One of the easiest methods for creating better airflow in the building is installing air conditioning systems. Air conditioners can keep the air purified by filtering out the air's pollen, dust, and mould spores.
- **Air changes and floor space:** The optimum floor space requirement per person ranges from 50 to 100 square feet, with ceiling heights not exceeding 10 to 12 feet high. A big spacious room can allow an easy flow of air.

7.1.5 Sanitising and Disinfacting Work Area

Cleaning with soap or detergent products reduces surface germs by removing contaminants and decreasing the risk of surface infection.

Disinfecting refers to using chemicals to kill germs on surfaces. This process does not clean dirty surfaces or remove germs but instead kills germs on a surface after cleaning and further lowers the risk of spreading infection.

Hard surfaces

- Cleaning and disinfection of frequently touched surfaces (i.e. tables, doorknobs, light switches, countertops, handles, desks, phones, and keyboards, should occur at least once a shift.
- Frequently touched surfaces should be cleaned in all personal work areas only.
- Before disinfection, heavily soiled surfaces should be cleaned first using a detergent or soap and water.
- Wear gloves when using either of the disinfectant products.
- Allow proper ventilation when using disinfectant products.
- Ensure the surface being disinfected remains wet for the required contact time
- Use your disinfectant sparingly. It is not necessary to saturate your work surface with disinfectant, and a light mist across the surface is sufficient.
- After meeting the required contact time, you may wipe off any excess disinfectant with a disposa-ble paper towel and place the towel in the regular trash.

Electronic Equipment

- Unplug all external power sources and cables.
- Never spray cleaner directly on an item rather, use a lint-free cloth, such as a screen wipe or a cloth made from microfiber.
- To prevent damage, avoid excessive wiping and submerging items in a cleanser.
- Do not use aerosol sprays, bleach, or abrasive cleaners to disinfect computers and electronics.
- Ensure moisture does not get into any openings
- Spray a small amount of the disinfectant on a soft cloth and wipe surfaces.
- Gently and carefully wipe the hard, nonporous surface of the electronic item. This includes the display, keyboard, mouse and the exterior surface of the item.
- If you have concerns about the cleaning product being used, please refer to the manufacturer's recommendations and warning label.
- When using a disinfectant wipe, it is crucial to follow the contact time found on the label. Using more than one wipe may be necessary to keep the surface wet for the recommended contact time.

UNIT 7.2: Importance of Safe Working Practices

Unit Objectives

By the end of this unit, the participants will be able to:

1. Explain Basic Hygiene Practices
2. Understand the importance of Social Distancing
3. Demonstrate the safe working practices

7.2.1 Basic Hygiene Practices

We are living in an environment with millions of germs and viruses. And our body can be a breeding space for these microbial organisms. They grow and multiply and cause many diseases which sometimes can prove to be fatal for the human beings. These disease-causing mi-crobial organisms kill over 17 million people every year. Some simple hacks and little changes of basic personal hygiene habits can bring amazing changes to all of us. We can prevent contracting these diseases if we follow these hygiene practices every day.

Personal Hygiene

Personal hygiene is all about managing your body hy-giene, essentially caring for your well-being incorporat-ing some physical hygiene habits. Also, there are mental health benefits as well, as they affect each other im-mensely.

What are good personal hygiene habits?

Good personal hygiene includes but not limited to-

- Take regular shower
- Maintain oral hygiene
- Wash your hands frequently
- Wash your genitals
- Keep your clothes and surrounding dry and clean

These habits should be practiced on a regular basis, at home, at work, basically where you are!

That's the whole idea of preventing your body system collapse over a tiny mi-crobe!

Personal Hygiene Practices at Home

Your home should be the most comfortable and conven-ient for you to keep up your personal hygiene level to a standard, yet, we find ourselves procrastinating over hygiene issues when we are at home. Even though some of these tasks barely take a minute.

1. **Take Regular shower**

   Do not wait up to feel the dried sweat in your body to feel the urge to take shower, make it a routine, you have the choice to either take them before you head to work or after the long day or even before you head to sleep, whichever one suits your routine. Make sure to rinse your body thoroughly, especially the genitals and underarms as they produce more sweat and are more prone to fungal activities.

2. **Wash your hands frequently**

   We use our hands to do our most physical acts, from picking up the keys, browsing through our phones, cooking or eating to attending our pets. While we agree and accept the importance of washing hands before eating and after visiting the toilet, it is also important to wash our hands with soap or sanitizer every now and then. The pandemic covid-19 which crippled the life all over the world has taught us an important lesson that sanitizing our hands regularly is the only way we can avoid transmission of the disease. Use alcohol based sanitizer to wash hands well to prevent the spread of communicable diseases.

Fig. 7.2.1: 7 steps for Handwashing

3. **Maintain oral hygiene practices**

   It is very important to take care of the teeth and gum, to prevent tooth decay and bad odour. Just brushing them twice a day is not enough, but using fluoride toothpaste and brushing properly is very essential. And wash it well with water to remove any food particles that is stuck in the gap in between the teeth. It is advised to wash the teeth everyday twice to maintain healthy teeth and gum.

4. **Nails and hairs hygiene**

   The cleanliness of nails and hair is also very important. They store dirt and grease. And even the microbes could be in there stuck and spreading. If the nail is not clean they can cause severe food poisoning, as we use our hands to eat food. Trim the nails once in a fortnight and wash hair at least twice a week with a shampoo to keep them healthy

5. **Nose and ears hygiene**

   Wherever we are most likely to breathe in some pollutants, and most of the particles are bound to be stuck in the nasal hair. So, rinse the nose and ear with warm water once you return from outside.

6. **Wear fresh and clean clothes**

   Changing into neat and clean clothes will prevent many infectious diseases. It will also give the mental effect immediately and it will boost the mind. Wash clothes with a good detergent every day and dry it in the sun. This will ward off any microbes attached to the clothes. If possible, Dettol can be used while rinsing which is an anti-disinfectant.

7. **Food hygiene**

   You can get severely sick from food-borne diseases, as most of your foods are raw, purchased from outside, they risk being cross-contaminated with harmful microbes. Food hygiene is basical-ly the idea of better storage, handling, and preparation of food to prevent contamination and to prevent food poisoning.

7.2.2 Importance of Social Distancing

Preventing communicable diseases:

All these above practices will help us to prevent communicable diseases. These diseases are highly infectious and contagious and spread through air, urine, feaces, saliva, skin (through touch) and using same towels and utensils.

Social Distancing and isolation, Self-Quarantine:

Ever since the spread of the pandemic covid-19, several health organisations have been insisting on following social distancing and isolation. Communicable diseases mainly spread through coming close to the infected individual and through physical touch. If a person is infected with diseases like normal flu or cold and spread it to others, the symptoms and may remain with the infected person for a day or two. The virus may be destroyed by taking an antibiotic. But in severe cases like corona virus the infection is severe and can prove fatal to the affected people. To prevent the spread of the virus, the entire world adopted lockdown, social distancing and compulsory face mask. And the infected person has to be in self isolation and quarantine till the time the symptoms are over. This was the advisory from the World Health Organisation, and the entire world followed it to prevent the rapid spread of the virus. The same can be applicable to all types of communicable diseases that are spread mainly through air and touch.

As communities reopen and people are more often in public after the pandemic, the term “physical distanc-ing” (instead of social distancing) is being used to rein-force the need to stay at least 6 feet from others, as well as wearing face masks. Historically, social distanc-ing was also used interchangeably to indicate physical distancing which is defined below. However, social dis-tancing is a strategy distinct from the physical distanc-ing behavior.

What is self-quarantine?

Self quarantine was imposed on people who have been exposed to the new covid-19 and who are at risk for getting infected with the virus were recommended to practice self-quarantine. Health experts advised the self-quarantine for 14 days or two weeks. Two weeks provides enough time for them to know whether or not they will become ill and be contagious to other people.

Self-quarantine was also recommended for people who have recently returned from traveling to a part of the country or the world where COVID-19 was spreading rapidly, or if a person has knowingly been exposed to an infected person.

Self-quarantine involves:

- Using standard hygiene and washing hands frequently
- Not sharing things like towels and utensils
- Staying at home
- Not having visitors
- Staying at least 6 feet away from other people in your household

Once your quarantine period has ended, if the symptoms are not there, then the person may return to normal routine as per doctor's advice.

What is isolation?

Anybody who is infected with a contagious disease needs to practice isolation in order to prevent the spread of the germs to their near and dear ones. This became very popular and was strictly adhered to during the covid-19 pandemic. People who were confirmed to have COVID-19, isolation was mandatory. Isolation is a health care term that means keeping people who are in-fected with a contagious illness away from those who are not infected. Isolation can take place at home or at a hospital or care facility. Special personal protective equipment will be used to care for these patients in health care settings. They are attended by well trained nurses and specialised doctors. And these people have to be in the PPE kits all through their presence in the hospital.

Fig. 8.3.2: Complete PPE Kit

Disposing off the PPE Kits

The PPE kits are worn by health workers and doctors who are attending to patients with highly infectious diseases and who are kept is isolation in order to arrest the spread. They have to wear it every time they go near the patient and have to remove it once their duty is over. Most of the PPE components are used for single use, however the face mask and goggles can be reused provided they are sanitised properly. The PPE kits have to be disposed off safely as they might have contaminants stuck to them and they may infect the healthy person if they are not discarded properly. The health workers may be all the more vulnerable to contact the disease.

7.2.3 Safe Workplace Practices

Every company has the provision of first aid box. As you have already read about the types of injuries that technicians can receive in their field of work, it is imperative for the companies to have appropriate first aid accessories.

The basic first aid supplies and accessories that a first aid box should have are:

Supplies and Accessories in the First Aid Box


Splint


Elastic wraps


Latex gloves


Adhesive tape


Tweezers


Blanket


Scissors


Wound cleaning agent


Triangular bandages


Gauze roller bandage


Adhesive bandages


Gauze pads


Antiseptic cleansing wipes


Burn cream or gel

Eyewash liquid

CPR Kit

Chemical hazards are caused by toxic materials, which are poisonous. And being poisonous in nature, they can either be fatal or cause serious damages in case the preventive actions are not taken on time. Now, the exposure to chemicals can be in 3 forms.

They can be:

- Inhaled (entering the body through nose)
- Directly in contact with skin
- Ingested (consumed)

The symptoms, in this case, will be:

- Seizures
- Partial or complete loss of responsiveness
- Burning sensation
- Stomach Cramping with bouts of excruciating pain
- Nausea
- Vomiting (and in times with blood-stains)

Now, where there are problem, their solutions come side by side. In such situations, the person giving first aid requires to be calm and take certain preventative actions.

Some of the essential actions are:

- Using insulated equipment
- Wearing protective clothing, goggles, masks, shoes and gloves
- Ensuring the place has enough ample ventilation

Remedial action

- The foremost thing that one should do is to provide immediate first aid. However, it is to be remembered that the victim should not be given any kind of fluid (water, milk) until doctors from Poison control unit gives a green signal.
- Aside from this, there are a few things a person can perform to the victim of toxic material exposure.
- Remove the victim from the toxic zone or vicinity
- Call for an ambulance

- Remove contaminated clothing
- Splash water in the eyes
- If ingested, do not try to make the victim puke (vomit)
- Wash their mouth with water

Fig. 8.3.3: CPR

- In case the victim's breathing has stopped, give CPR (Cardiopulmonary resuscitation)
- In case of burning due to toxic material, apply burn gel or water gel on that area.
- Avoid any cream based or oil based lotion or ointment
- Even though giving first aid is the right thing to do in the first place, it is also important to report the incident to their supervisor.

7.2.4 Stress Management

We say we are 'stressed' when we feel overloaded and unsure of our ability to deal with the pressures placed on us. Anything that challenges or threatens our well-being can be defined as stress. It is important to note that stress can be good and bad. While good stress keeps us going, negative stress undermines our mental and physical health. This is why it is so essential to managing nega-tive stress effectively.

Causes of Stress

Internal and external factors can cause stress.

Internal causes of stress:

- Constant worry
- Rigid thinking
- Unrealistic expectations
- Pessimism
- Negative self-talk
- All-in or all-out attitude

External causes of stress:

- Major life changes
- Difficulties with relationships

- Having too much to do
- Difficulties at workplace
- Financial difficulties
- Worrying about one's children and/or family

Symptoms of Stress

Stress can manifest itself in numerous ways. Take a look at stress's cognitive, emotional, physical and behavioural symptoms. Cognitive Symptoms of stress include lack of concentration, pessi-mism, anxiety and lack of judgement. The physical and behavioural symptoms of stress include:

Physical Symptom	Behavioural Symptoms
• Aches and pain • Diarrhoea or constipation • Nausea • Dizziness • Chest pain and/or rapid • heartbeat • Frequent cold or flu like feelings	• Increase or decrease in • appetite • Oversleeping or not sleeping enough • Withdrawing socially • Ignoring responsibilities • Consumption of alcohol or cigarettes • Nervous habits like nail biting, pacing etc.

The following tips can help you manage your stress better:

- Note down the different ways in which you can handle the various sources of your stress.
- Remember that you cannot control everything, but you can control how you respond.
- Discuss your feelings, opinions and beliefs rather than reacting angrily, defensively or passively.
- Practice relaxation techniques like meditation, yoga or tai chi when you start feeling stressed.
- Devote a part of your day towards exercise.
- Eat healthy foods like fruits and vegetables. Avoid unhealthy foods especially those containing large amounts of sugar.
- Plan your day so that you can manage your time better, with less stress.
- Say no to people and things when required.
- Schedule time to pursue your hobbies and interests.
- Ensure you get at least 7-8 hours of sleep.
- Reduce your caffeine intake.
- Increase the time spent with family and friends.

UNIT 7.3: Optimal Utilisation of Resources

Unit Objectives

By the end of this unit, the participants will be able to:

1. Discuss about efficient utilisation of material and water
2. State ways for efficient energy conservation

7.3.1 Efficient Utilisation of Water

Optimal utilisation of resources measures the value of a services team's most valuable asset, its people, by leveraging that asset in the most efficient way possible. Optimising resource utilisation and availability can help ensure project health, profit gains and sustainable growth.

Saving water in your workplace

Employee's contribution

- Talk to staff about your water savings initiatives. Include water savings policies and procedures in staff inductions.
- Encourage staff to contribute to water-saving ideas.
- Discuss water efficiency at team meetings and provide regular reports on water use figures.
- Appoint a 'water champion' to check meters and monitor water use.
- Establish a baseline for water use and set achievable targets for saving water.

Taps and bathroom fittings

- Install water-efficient taps with an aerator or flow restrictor to use less water.
- Fix leaking taps and replace washers - even a slowly dripping tap can waste 10,000 litres of water over a year.
- Avoid washing up under running taps.
- Replace single-flush toilets with dual-flush toilets.
- Install water-efficient urinals with smart controls to reduce unnecessary flushing.
- Install water-efficient shower heads, which can use up to 40% less water.

Gardens

- Install rainwater tanks.
- Use drought-tolerant plants.
- Use mulch to keep moisture in the soil.
- Water plants early in the morning or the evening.

Reducing water waste through recycling and reusing is another way to make a positive change. Installation of modern water systems that can recycle wastewater to supply different needs in your workplace or installing aerated faucet heads onto your taps to reduce the water flow is simple tips to make a real change.

Fig: Aerated faucet heads for taps

7.3.2 Reduce, Reuse, and Recycle

The 3R initiative aims to promote the "3Rs" (reduce, reuse and recycle) globally to build a sound-material-cycle society through the effective use of resources and materials.

Fig: Reduce, Reuse, Recycle

Environmental conservation is at the forefront of domestic and international discussion. Many people ask what they can do to reduce waste in their daily lives. We recycle, use energy-efficient bulbs, cut down on plastic, and do other things considered eco. In other words, there are many things we can change at home.

However, the workplace is equally important considering how much time many of us spend there. And while many companies have incorporated recycling and zero-waste policy, some businesses struggle to make their eco policy effective, especially in terms of paper consumption.

Despite technological advancements and digitalisation, many companies still use and waste an enormous amount of paper and ink.

Think before you print: When all you need to do to print is click an icon on your computer screen, it can be tempting to print anything without giving it much thought. Instead, you should consider whether you need to print that memo or document.

Maybe you can send it around via email, online fax, or share reading materials with a co-worker during a meeting. If a piece of paper gets tossed in the bin a short time after it's printed, you prob-ably don't need the information it contains to be in physical form, especially if you can't reuse it lat-er.

Application is equal to conservation: So many business-related tasks that used to rely on paper usage and exchange can now be done with apps. For instance, Slack is a great tool for team com-munication and file sharing. Evernote is easy, tidy, and has electronic project management, and Google docs is an effective way to collaborate on documents and spreadsheets without printing and paper.

And there are SO many more. It's time to find and adopt applications that can help your office save paper, time, and money. More importantly, incorporating such solutions is a huge step towards a paperless and green company, and it will also significantly improve efficiency at your workplace.

Print on both sides: As an environmentally conscious employer, take a moment to write down guidelines for two-sided printing. Specify which documents should be printed only on one side and which can utilise both sides. This eliminates confusion in employees and gives them an easy route to reducing paper waste.

It may not sound like a lot, but printing on two sides of the paper can significantly help your paper-saving goals. Sure, it won't eliminate paper sheet production, but it will certainly help reduce it, and that's one step closer to saving the environment.

Set up Direct Deposit: Also, embracing digital banking will significantly improve your business effi-cacy. Online transactions are much faster, safer, and easier to carry out. It's a classic win-win situa-tion that benefits your company and our planet.

Reduce label usage: Many offices use printed labels with their address that can stick onto the en-velope to be mailed out. Between the labels themselves, and the paper they are printed on (that ends up in the trash), a lot of paper gets wasted.

The eco-friendlier solution is to print addresses directly on the envelopes, and stamps can be printed too. Try to implement this strategy anywhere you would ordinarily use labels.

The best solution, of course, would be to eliminate traditional mail and switch to emailing instead. Of course, it's not always possible, and some documents (especially legal) have to be sent on pa-per. However, for any business-related things, you should always use email or other sources of in-ternal communication.

Archive electronically: Archiving information is a necessary practice for many offices. But filing cab-inets aren't the only way to store important documents. Not only does paper archival waste paper and office space, but it's also harder to search and sort.

Use email: No surprise you'd find this one on the list. Whether you're contacting employees, cli-ents, or companies who serve you, use email whenever possible. It's a fast, paper-free option that virtually everyone is familiar with and comfortable using. Most importantly, though, it's much faster than traditional mail, and you can be sure your documents won't get lost.

Take digital notes: It's practically impossible to have a meeting without writing an agenda and tak-ing notes. The first helps an employer run the meeting, whereas the latter allows the writing of a clear and structured meeting summary. The only problem is, handing a piece(s) of paper to all at-tendants is simply wasteful. Instead, try to do everything digitally.

An agenda can be sent using email, and someone can take notes using Google Docs or another sim-ilar program. You might even consider recording your meetings and then asking someone to make a digital transcript. That way, you won't use any paper and will still get everything done properly.

Buy recycled paper: You can buy paper that's been recycled, and it's available in all levels of thick-ness, and it won't change the printing performance or quality. Aside from recycled paper, you can also consider buying paper made from organic cotton, hemp, or pre-recycled paper. Doing that is a fantastic way to help the environment while keeping your paper needs intact.

UNIT 7.4: Waste Management

Unit Objectives

By the end of this unit, the participants will be able to:

1. Understand what is e-waste
2. Understand the concept of waste management
3. Explain the process of recycling of e-waste

7.4.1 Introduction to E-Waste

Electrical and electronic products are all around us. We can't imagine a world without these gadgets. Our life is indispensable without electricity and electronic devices. Growth in the IT and communication sectors has increased the usage of electronic equipment immensely. Frequent change on the technological features of electronic products is forcing consumers to discard their old electronic products very quickly, which, in turn, adds to e-waste to the solid waste pool. What this translates to is mountainous masses of electrical and electronic waste which has a high potential to pollute the environment. This growing menace of e-waste calls for a greater focus on recycling e-waste and better e-waste management.

E-waste means electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment, and repair processes. E-waste usually is made up of usable and non-usable material. Some of the waste if left unattended will be destructive to the environment. E-waste is made up of hazardous substances like lead, mercury, toxic material, and gases.

There are many companies these days who are engaged in the collection, handling, and disposal of this e-waste in a safer and more secure place to protect the environment.

7.4.1 What is E-Waste?

The amount of e-wastes comprising computers and computer parts, electronic devices, mobile phones, entertainment electronics, refrigerators, microwaves, TV, fridges, and industrial electronics that are obsolete or that have become unserviceable is growing. All these electronic devices contain plastics, ceramics, glass, and metals such as copper, lead, beryllium, cadmium, and mercury and all these metals are harmful to humans, animals, and the earth. Improper disposal only leads to poisoning the Earth and water and therefore all life forms. Our effort is meant to preserve the environment and prevent pollution by proper handling of e-waste. While it will take a lot of effort to educate people to dispose of such wastes in the right way, we are doing our part by providing a channel to collect e-wastes and dispose off them in a sustainably safe manner. We convert waste to usable resources.

The electronic industry is not only the world's largest industry but also a fast-growing manufacturing industry. It has been instrumental in the socio-economic and technological growth of the developing society of India.

At the same time, it poses a major threat in the form of e-waste or electronics waste which is causing harmful effects on the whole nation. e-waste is creating a new challenge to the already suffering Solid waste management, which is already a critical task in India.

7.4.3 Electronic Goods/gadgets are Classified Under Three Major Heads

White goods: Household appliances,

Brown goods: TVs, camcorders, cameras etc.,

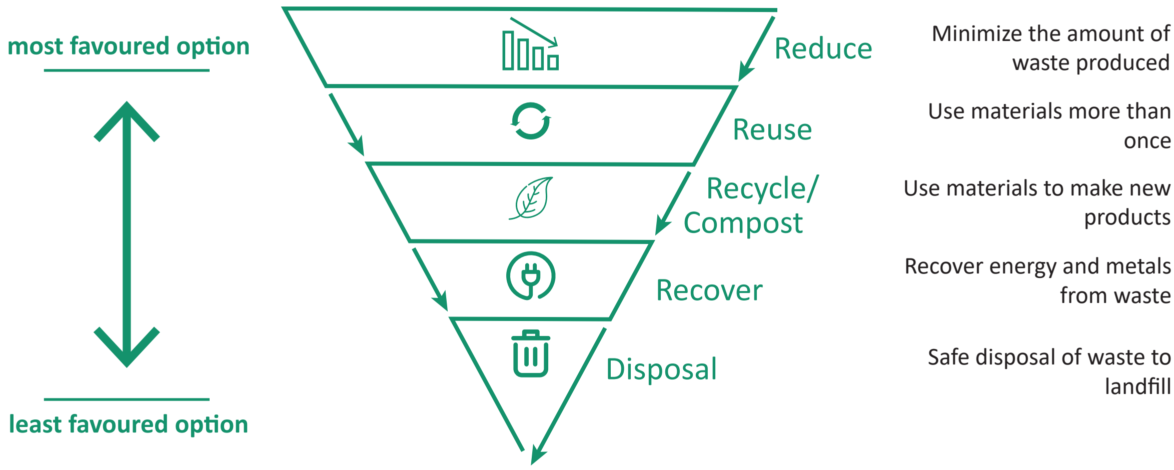
Grey goods: Computers, printers, fax machines, scanners etc.

The complete process is carried out as per the government guidelines.

7.4.4 E-waste Management Process

- Collection of e-waste from all the electronic stores, manufacturing companies, etc.
- Transport of e-waste to the disposal units
- Segregation of e-waste at the disposal unit
- Manual dismantling of e-waste to segregate components into various types such as metal, plastics and ceramics
- Convert into raw material (recycle and reuse)
- Supply recovered raw material to processors and electrical/electronic industries
- Dispatch hazardous e-waste for safe disposal

Waste management is carried out to ensure that all types of waste and garbage are collected, transported, and disposed of properly. It also includes recycling waste so that it can be used again.



7.4.5 Recyclable and Non-Recyclable Waste

Recyclable waste is renewable or can be reused. This means that the waste product is converted into new products or raw material, like paper, corrugated cardboard (OCC), glass, plastics containers and bags, hard plastic, metal, wood products, e-waste, textile, etc

Recycling not only conserves important areas in our landfills but also assists decrease greenhouse gas emissions.

Contrary to this, Non-recyclable waste cannot be recycled and cause a major threat to the environment.

The following items cannot be recycled:

Shredded paper, aerosol cans, paper coffee cups, milk and juice cans, used baby diapers, and bottle caps.

Recycling is one of the best ways to have a favorable influence on the world where we live.

Recycling will greatly help us to save both the environment and us from pollution. If we take immediate action, we can control this, as the quantity of waste we are accumulating is increasing all the time.

7.4.6 Colour Codes of Waste Collecting Bins

Waste collecting bins colour code

India's urban population of 429 million citizens produce a whopping 62 million tonnes of garbage every year. Out of this, 5.6 million tonnes is the plastic waste, 0.17 million tonnes is the biomedical waste, 7.90 million tonnes is hazardous waste and 15 lakh tonnes is e-waste.

According to an estimate, 40% of municipal waste in the city is 'wet' waste, which can easily be composted and used as manure. Nearly 30% of the municipal waste comprises of plastic and metal, which can be sent to an authorized dealer for recycling, and about 20% of it is e-waste, from which precious metals can be taken apart and recycled. However, out of the total municipal waste collected, 94% is dumped on land and only 5% is composted. To gather the garbage two color bin system was suggested. Green bin for wet waste and blue for dry waste. However, there is a drawback in that system. People do through the sanitary napkins and children's diaper along with wet waste causing the contamination of things. Hence the government has come up with three colored garbage collection bins.

1. **Green Bin**

   The green coloured bin is used to dump biodegradable waste. This bin could be used to dispose off wet/organic material including cooked food/leftover food, vegetable/fruit peels, egg shell, rotten eggs, chicken/fish bones, tea bags/coffee grinds, coconut shells and garden waste including fallen leaves/twigs or the puja flowers/garlands will all go into the green bin.

2. **Blue bin**

   The blue coloured bin is used for segregating dry or recyclable left over. This category includes waste like plastic covers, bottles, boxes, cups, toffee wrappers, soap or chocolate wrapper and paper waste including magazines, newspapers, tetra packs, cardboard cartons, pizza boxes or paper cups/plates will have to be thrown into the white bin. Metallic items like tins/cans foil paper and containers and even the dry waste including cosmetics, hair, rubber/thermocol (polystyrene), old mops/dusters/sponges.

3. **Black bin**

   Black bin, make up for the third category, which is used for domestic hazardous waste like sanitary napkins, diapers, blades, bandages, CFL, tube light, printer cartridges, broken thermometer, batteries, button cells, expired medicine etc.

7.4.7 Waste Disposal Methods

- Incineration: Combusting waste in a controlled manner to minimize incombustible matter like waste gas and ash.
- Waste Compaction: Waste materials are compacted in blocks and are further sent away for recycling.
- Landfill: Waste that can't be recycled or reused can be thinly spread out in the low-lying areas of the city.
- Composting: Decay of organic material over time by microorganisms.
- Biogas Generation: With the help of fungi, bacteria, and microbes, biodegradable waste is converted to biogas in bio-degradation plants.
- Vermicomposting: Transforming the organic waste into nutrient-rich manure by degradation through worms.

7.4.8 Sources of Waste

1. **Construction waste –** waste coming from construction or demolition of buildings.
2. **Commercial waste-** waste from commercial enterprises
3. **Household waste-** garbage from households is either organic or inorganic
4. **Medical or clinical waste -** wastes from the medical facilities- like used needles and syringes, surgical wastes, blood, wound dressing
5. **Agricultural waste-** Waste generated by agricultural activities that include empty pesticide containers, old silage packages, obsolete medicines, used tires, extra milk, cocoa pods, wheat husks, chemical fertilizers, etc.
6. **Industrial waste-** The waste from manufacturing and processing industries like cement plants, chemical plants, textile, and power plants
7. **Electronic waste-** The defective, non-working electronic appliances are referred to as electronic waste. These are also called e-waste. Some e-waste (such as televisions) contains lead, mercury, and cadmium, which are harmful to humans and the environment
8. **Mining waste-** chemical gases emitted in mine blasting pollutes the environment. And the mining activity greatly alters the environment and nature.
9. **Chemical waste-** waste from the chemical substance is called chemical waste.
10. **Radioactive waste-** radioactive waste includes nuclear reactors, extraction of radioactive materials, and atomic explosions.

7.4.9 Source of Pollution

All these above-mentioned waste also adds to environmental pollution.

The contaminants that cause detrimental change to the environment are called pollution. It is one of the most serious problems faced by humanity and other life forms on our planet. The earth's physical and biological components have been affected to such an extent that normal environmental processes could not be carried out properly.

7.4.10 Types of Pollution

Types of Pollution	Detail/Pollutants involved
Air pollution	• Solid particles and gases mixed in the air cause air pollution • Pollutants: emissions from the car, factories emitting chemical dust, and pollen
Water pollution	• Water gets polluted when toxic substances enter water bodies such as lakes, rivers, oceans, and so on. They get dissolved in it and cause it unfit for consumption. • Pollutants that contaminate the water are discharges of untreated sewage, and chemical contaminants, release of waste and contaminants into surface
Soil pollution	• It is the presence of toxic chemicals (pollutants or contaminants) in soil, in high enough concentrations to pose a risk to human health and/or the ecosystem • Sources of soil pollution include metals, inorganic ions, and salts (e.g. phosphates, carbonates, sulfates, nitrates),
Noise pollution	• Noise pollution happens when the sound coming from planes, industry or other sources reaches harmful levels • Underwater noise pollution coming from ships has been shown to upset whales' navigation systems and kill other species that depend on the natural underwater world
Light pollution	• Light pollution is the excess amount of light in the night sky. • Light pollution, also called photo pollution, is almost always found in urban areas. • Light pollution can disrupt ecosystems by confusing the distinction between night and day.

Summary

- Safety is the responsibility of all employees, whether at the job site or in a factory.
- Every organization is obligated to ensure that the workplace follows the highest possible safety protocol.
- A hazard is a source of potential damage or adverse health effects on something or someone.
- The work area should be in a clean and tidy condition
- Any job role and any occupation in this world have some hazards, in varying severity, associated with it. These are called Occupational Hazards.
- Disinfecting refers to using chemicals to kill germs on surfaces.
- An escalation matrix is made up of several levels of contact based on the specific problem at hand.
- Optimising resource utilisation and availability can help ensure project health, profit gains and sustainable growth.
- E-waste means electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment, and repair processes.
- We say we are 'stressed' when we feel overloaded and unsure of our ability to deal with the pressures placed on us. Anything that challenges or threatens our well-being can be defined as stress.
- Recycling is one of the best ways to have a favourable influence on the world where we live.
- The 3R initiative aims to promote the "3Rs" (reduce, reuse and recycle) globally to build a sound-material-cycle society through the effective use of resources and materials.

Exercise

Multiple-choice Questions

1. CPR is _________.

   a. Cardio Pulmonary Resuscitation | b. Cardio Pulmonary Restriction

   c. Central Pulmonary Resuscitation | d. Cardio Pulsive Resuscitation

2. 2. Combusting waste in a controlled manner to minimize incombustible matter like waste gas and ash is called__________

   a. Incineration | b. Vermicomposting

   c. Waste Compaction | d. Composting

3. Decay of organic material over time by microorganisms is known as ________.

   a. Waste Compaction | b. Incineration

   c. Composting | d. Vermicomposting

4. Internal causes of stress include:

   a. Rigid thinking | b. Unrealistic expectations

   c. Pessimism | d. All of the above

5. Spending a large portion of your workday at the computer can cause _______.
   a. Eyestrain
   b. Physical injuries
   c. Ergonomic Injuries
   d. None of the above

Answer the following:

1. Explain the steps of CPR
2. What are organisational hazards?
3. How to clean electronic equipment?
4. Explain the steps for water conservation at workplace?
5. Explain various waste disposal methods.

Notes

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8. Annexure

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